

ESTIMATING EXPECTED HEALTH OPPORTUNITY COSTS IN THE NHS

(Analysis of 2004/05 Expenditure Data)

YORK TEAM

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Summary

This document comprises of two appendices:

Summary of Appendix 1: Outline of data update, estimation strategy, and results for outcome and expenditure models for 2004/05

Starting point: the 2005/06 specification

1. Identify the preferred specification for the outcome and expenditure equation for each programme budget category (PBC) for 2005/06. The outcome and expenditure elasticities generated by these specifications (when estimated at LA-level) are shown in Table 1.

Re-estimate the 2005/06 specifications using updated data

2. The 2005/06 specifications were derived using a combination PCT-level data mapped to LA-level and direct LA-level data. Backdate PCT-level data to 2004/05 and put backdated PCT-level data through the appropriate mapper to obtain LA-level data. This will include backdating and mapping:

- the PB expenditure data from 2005/06 to 2004/05
- the raw population, unified weighted population, and MFF estimates used and implied by the resource allocations for 2004/05
- PB specific indices of need (eg infectious diseases, mental health, maternity) from the relevant DH resource allocation exposition books (where possible)
- PB specific disease prevalence rates as extracted from the HSCIC's QOF database (where possible).

Note that the PB data for 2004/05 was originally generated for the then 303 PCTs. This has been converted to the new 152 (since October 2006) PCT boundaries by the DH.

3. Obtain LA-level statistics for those variables that are reported at this unit of analysis. This will involve backdating LA-level data for 2005/06 to 2004/05. This will include backdating :

- mortality data for 2005/06/07 with data for 2004/05/06
- census-based variables for 2005 with data for 2004 (by appropriate interpolation between 2001 and 2011).

Complications: (i) no data for CKD prevalence for 2004/5, 2005/6 and 2006/7 so we use 2007/8 as a proxy for all three years; (ii) prevalence rates for diabetes and epilepsy for 2004/5 are available by PCT but these rates are for the set of PCTs prior to the re-organisation in October 2006 (n=303). Without a mapper for this re-organisation, we use the prevalence rates for 2006/7 as proxies for the rates in 2004/5; (iii) a similar issue affects the IMD2007 and we have persevered with this here rather than investigating the IMD2004 (remember the IMD2004 uses data from 1997 to 2003); (iv) there were some relatively small boundary changes for local government in April 2009. We persevere with this geography by adjusting the reported pre-April 2009 mortality rates so that they relate to the post-2009 boundaries as closely as possible.

More precisely, the re-organisation of local government created nine new unitary authorities (UAs). Five of these were created from existing county councils and their district councils. The remaining four new UAs were created by splitting Cheshire and Bedfordshire into two each along existing district council boundaries. The nine unitary authorities are, therefore, all aggregates of existing local authorities. Further details of the re-organisation are shown below:

- Bedford UA was formed from Bedford District Council.
- Central Bedfordshire UA was formed from Mid Beds and South Beds District Councils.
- Cheshire East UA was formed from Congleton, Crewe & Nantwich and Macclesfield District Councils.
- Cheshire West and Chester UA was formed from Chester, Ellesmere Port and Vale Royal District Councils.
- Cornwall UA was formed from the Caradon, Carrick, Kerrier, North Cornwall, Penwith and Restormel District Councils (i.e., equals Cornwall county council except the Isles of Scilly).
- County Durham UA was formed from Chester-le-Street, Derwentside, Durham, Easington, Sedgefield, Teesdale and Wear Valley District Councils (i.e., Durham county council).
- Northumberland UA was formed from Alnwick, Berwick-upon-Tweed, Blyth Valley, Castle Morpeth, Tynedale and Wansbeck District Councils (i.e., Northumberland county council).
- Shropshire UA was formed from Bridgnorth, North Shropshire, Oswestry, Shrewsbury and South Shropshire District Councils (i.e., Shropshire county council).
- Wiltshire UA was formed from Kennet, North Wiltshire, Salisbury and West Wiltshire District Councils (i.e., Wiltshire county council).

The transition of Bedford from a district council (DC) to a UA poses no problems for us as mortality data for all district councils are routinely reported by the HSCIC. Thus we can backdate our UA-level data using DC data.

There is an issue with Bedfordshire UA and the two Cheshire UAs. How do we combine the mortality rates for the two or three component DCs to reflect the post-2009 UA boundaries? Population estimates for these DCs are readily available for 2000 (latest available from the NOMIS website) so we used these as weights so that we could combine the DC mortality rates to form the estimated UA mortality rates. Ideally, of course, we would use mortality and population data by age group and year for each of these DCs for each of the study periods to form the relevant UA data. But this would be a considerable undertaking (even if we could get the data) and it is not obvious that such an exercise would involve a sensible use of project resources (not least because only three UAs are affected).

Finally, there is a very slight discontinuity with the Cornwall data. We use the Cornwall county council mortality data for pre-2009 as a proxy for Cornwall UA data. The difference here is that the

UA (population in 2000 is 495,400) excludes the Isles of Scilly (population 2,100) but the County Council includes it.

Estimation strategy for 2004/05: same as for 2005/06

4. Having backdated all data, use the preferred specification for 2005/06 to re-estimate each outcome and expenditure equation for 2004/05.
5. If this re-estimation produces a result which (a) passes the appropriate statistical tests and (b) generates coefficients in line with theoretical priors, use this result as our preferred result for 2004/05. This rule is applied to cases where the preferred specification for 2005/06 is either IV or OLS. If this re-estimation produces an acceptable result, the resulting elasticity shown in Table 1 has a '--' in the next column.
6. If the re-estimation produces a result which does not pass tests/have coefficients in line with priors, re-estimate the equation having adjusted the specification as suggested by the initial result. So, for example, if the initial estimation implies the presence of weak instruments and one of the instruments is insignificant in the first-stage regression, try re-estimating the equation without the insignificant instrument. And if, for example, one of the regressors in the second-stage regression is insignificant, try re-estimating without it. If this re-estimation produces an acceptable result, the resulting elasticity shown in Table 1 has an 'A' in the next column.
7. If a relatively minor adjustment to the 2005/06 specification does not generate a statistically and theoretically acceptable result, re-derive the IV equation to be estimated (again, this applies to cases where the preferred specification for 2005/06 is either IV or OLS). That is, use OLS with backward stepwise regression to identify relevant covariates to be included in the second-stage regression having forced in the relevant variables throughout. For the outcome equation we force in own programme expenditure, and for the expenditure equation the other programme need variable and the total budget term are forced in throughout the stepwise procedure.
8. Having identified relevant covariates for the second-stage regression, again use stepwise backward regression to identify relevant instruments for the first-stage conditioning on the covariates for the second-stage identified above. In other words, these second-stage covariates are forced in throughout stepwise procedure to identify relevant instruments.
9. Having identified covariates for the second-stage (in 7 above) and instruments for the first-stage (in 8 above), re-estimate the IV specification equation using these two sets of variables. If the endogeneity test suggests that a variable (eg own programme expenditure in the outcome equation) is clearly not endogenous then re-estimate using OLS. If this re-estimation produces an acceptable result, the resulting elasticity shown in Table 1 has a 'B' in the next column.
10. If the above re-estimation approach produces a result which does not pass tests/have coefficients in line with priors, re-estimate the equation having adjusted the specification as suggested by the initial result (for example, if the result fails the misspecification test try adding the squared value of one of the regressors to the specification). If this re-estimation produces an acceptable result, the resulting elasticity shown in Table 1 has a 'C' in the next column.

11. If all of the above approaches fail to produce an acceptable result, consider excluding PCTs with extreme values of expenditure per person. Only explore this option for programmes with small amounts of expenditure and/or mortality. If this re-estimation approach produces an acceptable result, the resulting elasticity shown in Table 1 has a 'D' in the next column.

Results for 2004/05: elasticities from preferred specifications

12. The estimation strategy outlined above generated the outcome and expenditure elasticities for 2004/05 shown in Table 1.

Results for 2004/05: full IV/OLS result for preferred specifications

13. The full result [IV (second-stage) or OLS] associated with each elasticity reported in Table 1 can be found in Table A3 (for the outcome equations) and Table A4 (for the expenditure equations) in the appendix.

Results for 2004/05: estimation path to preferred specifications

14. The full estimation path for each result (starting with the re-estimation of the 2005/06 specification with updated data) can be found in Table A5 (for the outcome equations) and Table A6 (for the expenditure equations) in the appendix.

Table 1 Outcome and expenditure elasticities for 2004/05, 2005/06, 2006/07, 2007/08, 2008/09 and 2009/10

PBC #	PBC description	for 2009/10				for 2008/09				for 2007/08				for 2006/07				for 2005/06				for 2004/05				for 2003/04			
		Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P
1	Infectious diseases	-0.310*	A	0.968***	--	-0.549***	A	147***	--	-0.660**	A	1387***	--	-0.608	A	105***	A	-0.432	--	1205***	--	-0.100	A	0.932***	A				
2	Cancers and tumours	-0.345***	--	0.502**	A	-0.287***	--	0.784**	--	-0.273***	--	1626***	A	-0.239***	A	1219***	--	-0.159*	A	1592***	A	-0.224**	--	1259***	--				
3	Diseases of the blood	n/a		1060***	B	n/a		0.995***	--	n/a		1374***	--	n/a		1037***	--	n/a		1486***	--	n/a		0.952***	A				
4	Endocrine, nutritional, metabolic	-1075**	A	0.708***	--	-1607**	--	0.498**	A	-1491	D	0.455***	--	-1464	A	0.630***	A	-1035	--	0.663***	--	-1843	A	0.573***	A				
5	Mental health disorders	n/a		0.899***	--	n/a		0.995***	--	n/a		1103***	--	n/a		1143***	--	n/a		0.991**	--	n/a		0.999***	--				
6	Learning disability	n/a		0.647**	B	n/a		0.329	--	n/a		0.386	--	n/a		0.410	B	n/a		0.449*	D	n/a		0.446*	--				
7	Neurological problems	-1357	C	0.850***	--	-0.304	C	0.897***	--	-0.237*	B	0.733***	A	-0.869*	D	0.382*	A	-0.325	A	1220***	--	-0.968**	A	0.929***	--				
8	Vision problems	n/a		0.934***	A	n/a		0.701**	--	n/a		1106***	C	n/a		0.931***	--	n/a		1127***	--	n/a		1350***	--				
9	Hearing problems	n/a		1273***	C	n/a		1637***	--	n/a		0.951*	A	n/a		0.989**	--	n/a		0.762**	--	n/a		0.526	C				
10	Circulatory problems	-1842***	--	0.494*	--	-1384***	--	1784***	A	-1315***	A	1614***	--	-1404***	--	1578***	--	-1637***	A	1477***	--	-1375***	A	1652***	--				
11	Respiratory problems	-2.103***	B	0.576***	--	-1671**	--	0.752**	--	-1564***	A	1555***	A	-2.281***	--	1287***	--	-2.217***	A	1225***	A	-2.494***	A	1253***	--				
12	Dental problems	n/a		0.765***	B	n/a		0.428**	B	n/a		0.420***	D	n/a		0.835**	C	n/a		See text	n/a	n/a		See text	n/a				
13	Gastro-intestinal problems	-1989*	A	0.387*	--	-1146**	A	0.520*	--	-0.837**	--	1490***	A	-1255**	--	1014***	A	-1014*	--	1076***	--	-1253***	--	0.928***	--				
14	Skin problems	n/a		0.890***	D	n/a		0.907***	--	n/a		0.787***	--	n/a		0.701**	A	n/a		0.840***	A	n/a		0.595***	A				
15	Musculo-skeletal problems	n/a		0.295	B	n/a		0.738***	C	n/a		0.733***	--	n/a		0.628**	A	n/a		0.935***	--	n/a		0.567***	--				
16	Trauma and injuries	0	n/a	1090***	--	0	n/a	1344***	--	-0.638	n/a	1328***	--	0	n/a	0.705***	--	Tbc		0.897***	A	Tbc		0.576**	A				
17	Genito-urinary problems	-2.997	B	0.878***	--	-0.024	C	0.733***	--	-1977	C	1015***	A	-0.588	D	0.988***	A	-0.869*	A	1079***	--	-0.931*	--	0.716***	A				
18	Maternity and reproductive health	-0.166*	B	0.653***	--	-0.030	A	0.963***	--	-0.057	--	0.563**	--	-0.085	C	0.614**	--	-0.056	B	0.865***	--	-0.121	--	0.678***	A				
19	Neonates																												
20	Poisoning and adverse events	n/a		0.658**	--	n/a		2.102***	--	n/a		1674***	A	n/a		1107***	--	n/a		1735***	--	n/a		1674***	--				
21	Healthy individuals	n/a		1246**	--	n/a		1049	--	n/a		1296**	C	n/a		0.709	B	n/a		0.507	B	n/a		0.709*	A				
22	Social care needs	n/a		0.844	B	n/a		1192*	--	n/a		1669**	C	n/a		1702***	--	n/a		1069*	--	n/a		1313**	--				
23	Other (includes GMS/FMS)	n/a		0.564***	B	n/a		0.338***	--	n/a		0.553***	--	n/a		0.447***	A	n/a		0.532***	--	n/a		0.337***	--				

Notes: (i) see pp3-4 of text for the meaning of the symbols in 're-estimation' columns;

(ii) the 're-estimation' columns for 2009/10 refer to a comparison of the preferred specification for 2009/10 at LA level with the preferred specification for 2008/09 at PCT level.

Summary of Appendix 2: Expected health opportunity costs in the NHS (2004/05 results)

Overview

15. In the second appendix results are presented that reflect the available data for 2004/05 expenditure (this forms Appendix 2.1). In Appendix 2.2, the results are also analysed in terms of how sensitive the results are to two key inputs: i) each of the estimated elasticities and ii) assumptions made in order to overcome data limitations for each PBC (only have mortality outcome data and for only a portion of PBCs). Finally, Appendix 2.3 briefly considers an update regarding data from ONS used to inform burden of disease.

Results

16. Results are presented in two ways as the point estimate of the cost per QALY of marginal activity in the NHS, or alternatively expressed as the expected QALY health opportunity cost for £10,000,000 expenditure.

Table 2 Probabilistic results for 2004/05 compared to previously generated results

2004/05	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£5,389	£5,377	£4,110	£7,517
Health opportunity costs of £10mn (QALYs)	1,856	1,860	1,330	2,433
2005/06	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£7,613	£7,635	£5,611	£11,619
Health opportunity costs of £10mn (QALYs)	1,314	1,310	861	1,782
2006/07	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£6,844	£6,838	£5,139	£9,878
Health opportunity costs of £10mn (QALYs)	1,461	1,462	1,012	1,946
2007/08	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£9,747	£9,765	£7,689	£13,043
Health opportunity costs of £10mn (QALYs)	1,026	1,024	767	1,301
2008/09	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£12,960	£13,271	£8,390	£32,881
Health opportunity costs of £10mn (QALYs)	772	754	304	1,192
2009/10	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£9,887	£9,920	£6,802	£17,296
Health opportunity costs of £10mn (QALYs)	1,011	1,008	578	1,470

It can be seen from Table 2 that the expected health opportunity costs of a change in expenditure have increased slightly between 2005/06 and 2004/04 and so the cost per QALY ratio has fallen. In this table, the uncertainty associated with these estimates is shown and it can be judged to what extent any changes in the point estimate between years should be interpreted as a signal of any

trend. From Table 2 it is hard to conclude that there is a significant change in the health opportunity costs of £10mn expenditure, since there is a great deal of overlap between the 90% confidence intervals of the years shown. The health opportunity costs of £10mn in 2004/05 are estimated to be significantly greater than those estimated for 2007/08 as shown by the lack of overlap between the 90% confidence intervals.

Figure 1 Results illustrating uncertainty for 2004/05 and previously generated results – cost per QALY

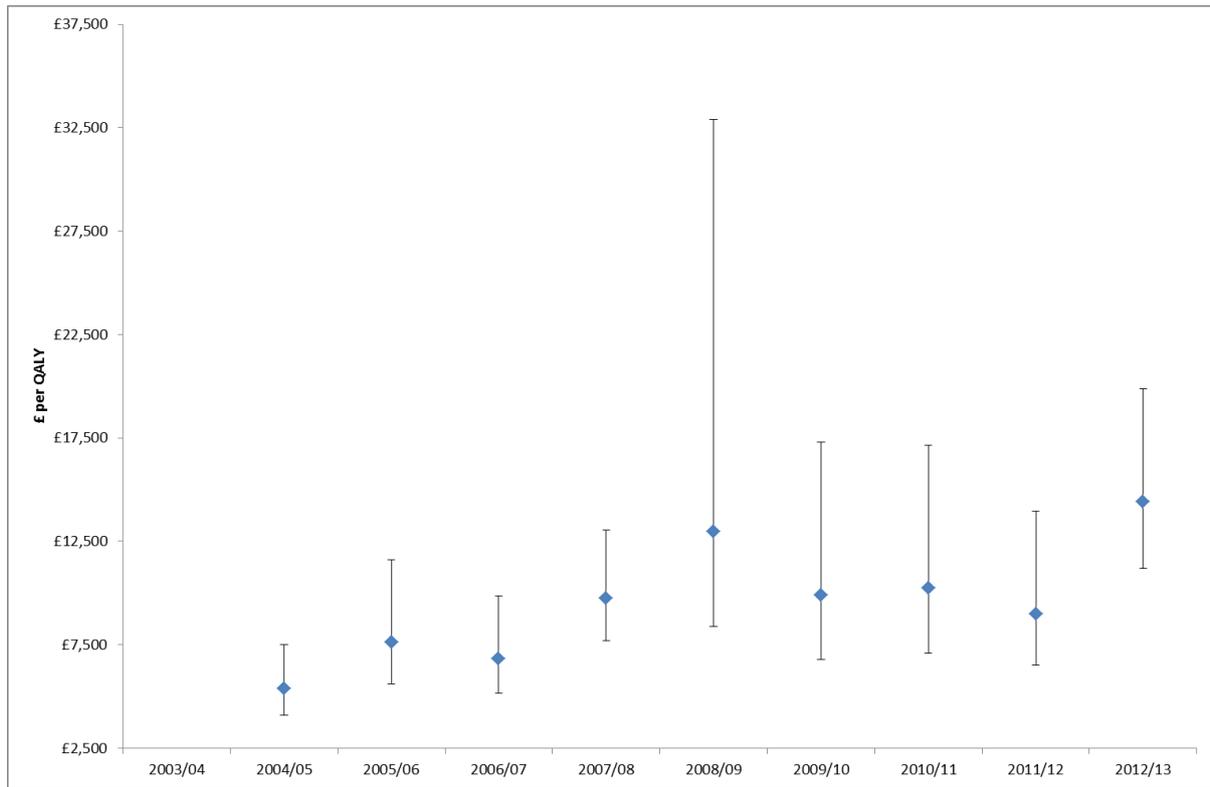
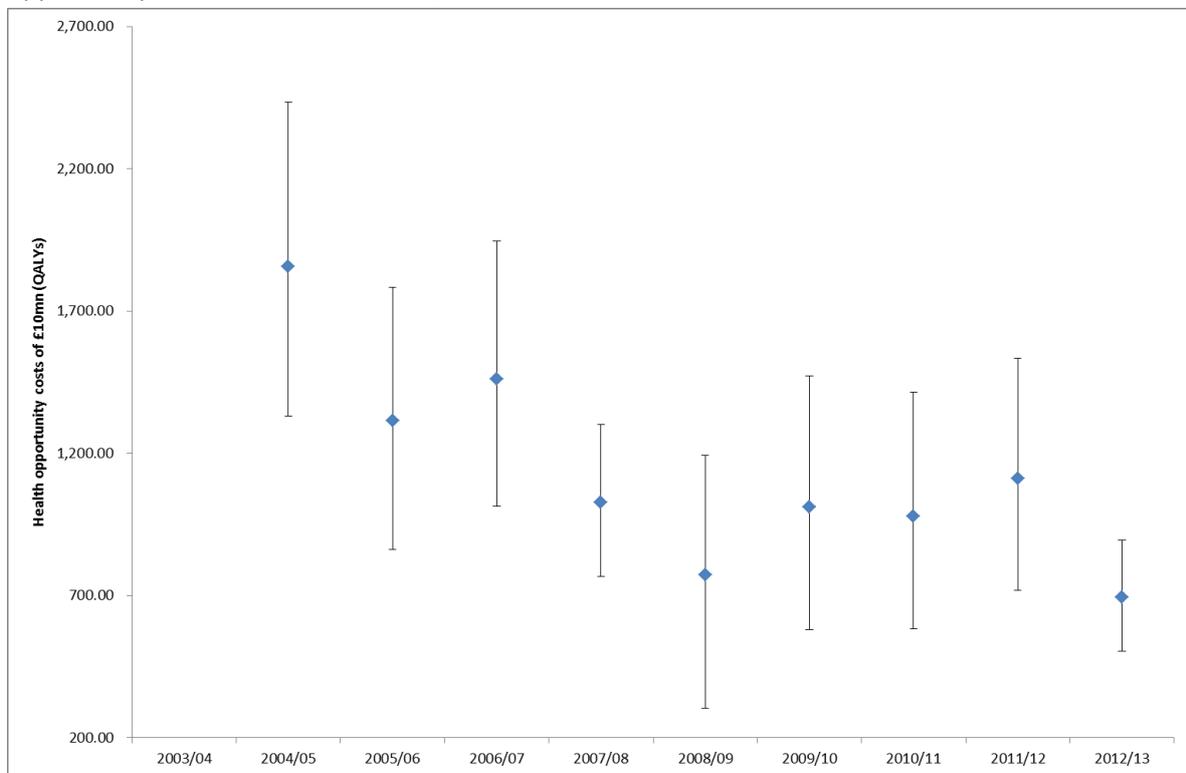


Figure 2 Results illustrating uncertainty for 2004/05 and previously generated results – Health opportunity costs of £10mn (QALYs)



17. It can also be seen from Figures 1 and 2 that while the confidence interval is far from symmetrically distributed around the point estimate of the cost per QALY ratio in Figure 1 (where uncertainty is reflected in the denominator), when expressed as health opportunity costs per £10mn then the distribution of uncertainty is much more symmetric in Figure 2 (uncertainty is reflected in the numerator).

Sensitivity analysis

18. Appendix 2.2 details three sensitivity analyses that were performed. The first two concerned the elasticities that were econometrically estimated for each of the PBCs. In the first case each of the estimated PBC outcome elasticities are varied by +/- 1 standard error. Then, the difference between the two resulting opportunity costs is presented. When this is larger, this implies that the overall resulting estimate of health opportunity costs is more sensitive to the outcome elasticity under consideration. The same procedure is then carried out for each of the PBC expenditure elasticities. The results of these sensitivity analyses are reported in Tables 3 and 4, with analysis and interpretation found in Appendix 2.2.

Table 3 Sensitivity of results to estimated outcome elasticities

	Change in spend	Change in QALY death + QALY alive	Implied PBC cost per QALY (£)	Difference in health opportunity costs between +1 SE and -1 SE in PBC outcome elasticity	% difference in health opportunity costs between +1 SE and -1 SE in PBC outcome elasticity	Importance of PBC (rank)	Importance of PBC (rank) 2005/06	Importance of PBC (rank) 2006/07	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2 Cancer	£ 891,450.47	49	£ 18,010.10	68	3.69%	6	6	6	5	6
10 Circulatory	£ 1,894,857.91	345	£ 5,486.45	165	8.89%	3	3	2	3	4
11 Respiratory	£ 736,592.21	657	£ 1,121.13	512	27.58%	1	1	1	1	2
13 Gastro-intestinal	£ 636,959.01	86	£ 7,380.94	70	3.80%	5	5	4	4	5
1 Infectious diseases	£ 176,604.68	2	£ 81,496.11	5	0.28%	8	7	7	8	7
4 Endocrine	£ 171,098.38	124	£ 1,385.07	156	8.39%	4	4	3	2	3
7 Neurological	£ 305,588.04	219	£ 1,395.10	226	12.17%	2	2	5	6	1
17 Genito-urinary	£ 418,666.65	6	£ 71,170.46	11	0.59%	7	8	8	7	8
16 Trauma & injuries*	£ 389,471.23	0	N/A	-	-	-	-	-	-	-
18+19 Maternity & neonates*	£ 438,369.80	0	£ 3,065,589.00	0	0.01%	9	9	9	9	9
3 Disorders of Blood	£ 151,688.57	39	£ 3,913.33	-	-	-	-	-	-	-
5 Mental Health	£ 1,374,915.71	201	£ 6,854.56	-	-	-	-	-	-	-
6 Learning Disability	£ 181,316.31	3	£ 55,174.37	-	-	-	-	-	-	-
8 Problems of Vision	£ 349,845.26	19	£ 18,293.13	-	-	-	-	-	-	-
9 Problems of Hearing	£ 31,185.53	14	£ 2,308.45	-	-	-	-	-	-	-
12 Dental problems	£ 107,731.54	25	£ 4,390.74	-	-	-	-	-	-	-
14 Skin	£ 138,849.80	4	£ 37,032.09	-	-	-	-	-	-	-
15 Musculo skeletal	£ 381,162.46	57	£ 6,699.23	-	-	-	-	-	-	-
20 Poisoning and AE	£ 193,346.73	5	£ 36,384.72	-	-	-	-	-	-	-
21 Healthy Individuals	£ 151,313.90	1	£ 159,784.55	-	-	-	-	-	-	-
22 Social Care Needs	£ 380,662.29	0	N/A	-	-	-	-	-	-	-
23 Other	£ 498,323.53	0	N/A	-	-	-	-	-	-	-

Total: 1,856

Table 4 Sensitivity of overall results to estimated spend elasticities

	Change in spend	Change in QALY death + QALY alive	Implied PBC cost per QALY (£)	Difference in health opportunity costs between +1 SE and -1 SE in PBC spend elasticity	% difference in health opportunity costs between +1 SE and -1 SE in PBC spend elasticity	Importance of PBC (rank)	Importance of PBC (rank) 2005/06	Importance of PBC (rank) 2006/07	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2 Cancer	£ 891,450.47	49	£ 18,010.10	66	3.58%	4	4	8	8	11
10 Circulatory	£ 1,894,857.91	345	£ 5,486.45	26	1.41%	12	2	9	2	2
11 Respiratory	£ 736,592.21	657	£ 1,121.13	174	9.37%	1	1	1	1	1
13 Gastro-intestinal	£ 636,959.01	86	£ 7,380.94	20	1.08%	14	12	18	12	13
1 Infectious diseases	£ 176,604.68	2	£ 81,496.11	18	1.00%	16	14	19	21	19
4 Endocrine	£ 171,098.38	124	£ 1,385.07	33	1.78%	10	11	12	10	3
7 Neurological	£ 305,588.04	219	£ 1,395.10	69	3.70%	3	19	6	19	18
17 Genito-urinary	£ 418,666.65	6	£ 71,170.46	63	3.42%	5	5	4	11	6
16 Trauma & injuries*	£ 389,471.23	0	N/A	78	4.22%	2	3	7	6	8
18+19 Maternity & neonates*	£ 438,369.80	0	£ 3,065,589.00	50	2.67%	8	7	2	5	4
3 Disorders of Blood	£ 151,688.57	39	£ 3,913.33	8	0.43%	21	15	20	18	22
5 Mental Health	£ 1,374,915.71	201	£ 6,854.56	19	1.00%	15	20	15	20	12
6 Learning Disability	£ 181,316.31	3	£ 55,174.37	35	1.91%	9	9	5	7	10
8 Problems of Vision	£ 349,845.26	19	£ 18,293.13	22	1.17%	13	13	16	15	17
9 Problems of Hearing	£ 31,185.53	14	£ 2,308.45	12	0.65%	18	17	17	13	20
12 Dental problems	£ 107,731.54	25	£ 4,390.74	5	0.25%	22	21	11	14	14
14 Skin	£ 138,849.80	4	£ 37,032.09	15	0.81%	17	16	14	16	16
15 Musculo skeletal	£ 381,162.46	57	£ 6,699.23	8	0.43%	20	22	22	22	21
20 Poisoning and AE	£ 193,346.73	5	£ 36,384.72	11	0.58%	19	18	21	17	15
21 Healthy Individuals	£ 151,313.90	1	£ 159,784.55	31	1.70%	11	10	13	9	5
22 Social Care Needs	£ 380,662.29	0	N/A	55	2.96%	6	6	10	3	7
23 Other	£ 498,323.53	0	N/A	53	2.84%	7	8	3	4	9
Total:		1,856								

19. Following these two sensitivity analyses, a third is performed with a different emphasis, which analyses the sensitivity of the overall health opportunity cost estimate to two key assumptions:

Surrogacy- we are required to make an assumption about how the effect on mortality for PBCs with a mortality indicator can be used as a *surrogate* for the effect that expenditure has on morbidity (or health-related quality of life) in those PBCs.

Extrapolation- We are required to make an assumption about how the estimated effects on mortality found for PBCs with a mortality indicator can be *extrapolated* to the effect that expenditure has on mortality for those PBCs that do not have a mortality indicator.

In order to assess the impact of these assumptions on the overall results for the NHS, we evaluate the health effects of £10mn spending at the margin in the NHS when either:

- a) For PBCs with a mortality indicator: no surrogacy assumption, therefore expenditure has no effect on morbidity
- b) For PBCs without a mortality indicator: assume no health effects at all, neither on mortality (extrapolation assumption) nor morbidity (surrogacy assumption)

The results are found here in Table 5. Interpretation and analysis is found in Appendix 2.2.

Table 5 Sensitivity of overall results to surrogacy and extrapolation assumptions

	Change in spend	Change in QALY death	Change in QALY alive	Health opportunity costs sensitivity to mortality/morbidity assumption (%)	Importance of PBC (rank)	Importance of PBC (rank) 2005/06	Importance of PBC (rank) 2006/07	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2 Cancer	£ 891,450.47	46	4	-0.19%	15	16	15	14	14
10 Circulatory	£ 1,894,857.91	234	111	-5.98%	5	3	4	3	5
11 Respiratory	£ 736,592.21	14	643	-34.66%	1	1	1	1	1
13 Gastro-intestinal	£ 636,959.01	31	56	-3.00%	7	7	6	5	6
1 Infectious diseases	£ 176,604.68	0	2	-0.09%	17	12	11	10	10
4 Endocrine	£ 171,098.38	6	117	-6.31%	4	6	3	4	4
7 Neurological	£ 305,588.04	10	209	-11.26%	2	4	5	7	3
17 Genito-urinary	£ 418,666.65	1	5	-0.25%	13	13	13	11	18
16 Trauma & injuries*	£ 389,471.23	0	0	0.00%	-	-	-	-	-
18+19 Maternity & neonates*	£ 438,369.80	0	0	0.00%	19	19	19	19	19
3 Disorders of Blood	£ 151,688.57	2	37	-2.09%	8	8	8	8	9
5 Mental Health	£ 1,374,915.71	18	183	-10.81%	3	2	2	2	2
6 Learning Disability	£ 181,316.31	1	3	-0.18%	16	17	17	17	15
8 Problems of Vision	£ 349,845.26	1	18	-1.03%	10	11	12	12	12
9 Problems of Hearing	£ 31,185.53	0	13	-0.73%	11	10	9	9	8
12 Dental problems	£ 107,731.54	0	25	-1.32%	9	9	10	13	11
14 Skin	£ 138,849.80	1	2	-0.20%	14	15	14	16	13
15 Musculo skeletal	£ 381,162.46	3	54	-3.07%	6	5	7	6	7
20 Poisoning and AE	£ 193,346.73	1	4	-0.29%	12	14	16	15	16
21 Healthy Individuals	£ 151,313.90	0	1	-0.05%	18	18	18	18	17
22 Social Care Needs	£ 380,662.29	0	0	0.00%	-	-	-	-	-
23 Other	£ 498,323.53	0	0	0.00%	-	-	-	-	-
Total:		369	1,486						
Total change in QALY death + QALY alive			1,856						

Appendix 1: Outline of data update, estimation strategy, and results for outcome and expenditure models for 2004/05

Starting point: the 2005/06 specification

20. Identify the preferred specification for the outcome and expenditure equation for each programme budget category (PBC) for 2005/06. The outcome and expenditure elasticities generated by these specifications (when estimated at LA-level) are shown in Table A1.

Re-estimate the 2005/06 specifications using updated data

21. The 2005/06 specifications were derived using a combination PCT-level data mapped to LA-level and direct LA-level data. Backdate PCT-level data to 2004/05 and put backdated PCT-level data through the appropriate mapper to obtain LA-level data. This will include backdating and mapping:

- the PB expenditure data from 2005/06 to 2004/05
- the raw population, unified weighted population, and MFF estimates used and implied by the resource allocations for 2004/05
- PB specific indices of need (eg infectious diseases, mental health, maternity) from the relevant DH resource allocation exposition books (where possible)
- PB specific disease prevalence rates as extracted from the HSCIC's QOF database (where possible).

Note that the PB data for 2004/05 was originally generated for the then 303 PCTs. This has been converted to the new 152 (since October 2006) PCT boundaries by the DH.

22. Obtain LA-level statistics for those variables that are reported at this unit of analysis. This will involve backdating LA-level data for 2005/06 to 2004/05. This will include backdating :

- mortality data for 2005/06/07 with data for 2004/05/06
- census-based variables for 2005 with data for 2004 (by appropriate interpolation between 2001 and 2011).

Complications: (i) no data for CKD prevalence for 2004/5, 2005/6 and 2006/7 so we use 2007/8 as a proxy for all three years; (ii) prevalence rates for diabetes and epilepsy for 2004/5 are available by PCT but these rates are for the set of PCTs prior to the re-organisation in October 2006 (n=303). Without a mapper for this re-organisation, we use the prevalence rates for 2006/7 as proxies for the rates in 2004/5; (iii) a similar issue affects the IMD2007 and we have persevered with this here rather than investigating the IMD2004 (remember the IMD2004 uses data from 1997 to 2003); (iv) there were some relatively small boundary changes for local government in April 2009. We persevere with this geography by adjusting the reported pre-April 2009 mortality rates so that they relate to the post-2009 boundaries as closely as possible.

More precisely, the re-organisation of local government created nine new unitary authorities (UAs). Five of these were created from existing county councils and their district councils. The remaining four new UAs were created by splitting Cheshire and Bedfordshire into two each along existing

district council boundaries. The nine unitary authorities are, therefore, all aggregates of existing local authorities. Further details of the re-organisation are shown below:

- Bedford UA was formed from Bedford District Council.
- Central Bedfordshire UA was formed from Mid Beds and South Beds District Councils.
- Cheshire East UA was formed from Congleton, Crewe & Nantwich and Macclesfield District Councils.
- Cheshire West and Chester UA was formed from Chester, Ellesmere Port and Vale Royal District Councils.
- Cornwall UA was formed from the Caradon, Carrick, Kerrier, North Cornwall, Penwith and Restormel District Councils (i.e., equals Cornwall county council except the Isles of Scilly).
- County Durham UA was formed from Chester-le-Street, Derwentside, Durham, Easington, Sedgefield, Teesdale and Wear Valley District Councils (i.e., Durham county council).
- Northumberland UA was formed from Alnwick, Berwick-upon-Tweed, Blyth Valley, Castle Morpeth, Tynedale and Wansbeck District Councils (i.e., Northumberland county council).
- Shropshire UA was formed from Bridgnorth, North Shropshire, Oswestry, Shrewsbury and South Shropshire District Councils (i.e., Shropshire county council).
- Wiltshire UA was formed from Kennet, North Wiltshire, Salisbury and West Wiltshire District Councils (i.e., Wiltshire county council).

The transition of Bedford from a district council (DC) to a UA poses no problems for us as mortality data for all district councils are routinely reported by the HSCIC. Thus we can backdate our UA-level data using DC data.

There is an issue with Bedfordshire UA and the two Cheshire UAs. How do we combine the mortality rates for the two or three component DCs to reflect the post-2009 UA boundaries? Population estimates for these DCs are readily available for 2000 (latest available from the NOMIS website) so we used these as weights so that we could combine the DC mortality rates to form the estimated UA mortality rates. Ideally, of course, we would use mortality and population data by age group and year for each of these DCs for each of the study periods to form the relevant UA data. But this would be a considerable undertaking (even if we could get the data) and it is not obvious that such an exercise would involve a sensible use of project resources (not least because only three UAs are affected).

Finally, there is a very slight discontinuity with the Cornwall data. We use the Cornwall county council mortality data for pre-2009 as a proxy for Cornwall UA data. The difference here is that the UA (population in 2000 is 495,400) excludes the Isles of Scilly (population 2,100) but the County Council includes it.

Estimation strategy for 2004/05: same as for 2005/06

23. Having backdated all data, use the preferred specification for 2005/06 to re-estimate each outcome and expenditure equation for 2004/05.
24. If this re-estimation produces a result which (a) passes the appropriate statistical tests and (b) generates coefficients in line with theoretical priors, use this result as our preferred result for 2004/05. This rule is applied to cases where the preferred specification for 2005/06 is either IV or OLS. If this re-estimation produces an acceptable result, the resulting elasticity shown in Table A1 has a '--' in the next column.
25. If the re-estimation produces a result which does not pass tests/have coefficients in line with priors, re-estimate the equation having adjusted the specification as suggested by the initial result. So, for example, if the initial estimation implies the presence of weak instruments and one of the instruments is insignificant in the first-stage regression, try re-estimating the equation without the insignificant instrument. And if, for example, one of the regressors in the second-stage regression is insignificant, try re-estimating without it. If this re-estimation produces an acceptable result, the resulting elasticity shown in Table A1 has an 'A' in the next column.
26. If a relatively minor adjustment to the 2005/06 specification does not generate a statistically and theoretically acceptable result, re-derive the IV equation to be estimated (again, this applies to cases where the preferred specification for 2005/06 is either IV or OLS). That is, use OLS with backward stepwise regression to identify relevant covariates to be included in the second-stage regression having forced in the relevant variables throughout. For the outcome equation we force in own programme expenditure, and for the expenditure equation the other programme need variable and the total budget term are forced in throughout the stepwise procedure.
27. Having identified relevant covariates for the second-stage regression, again use stepwise backward regression to identify relevant instruments for the first-stage conditioning on the covariates for the second-stage identified above. In other words, these second-stage covariates are forced in throughout stepwise procedure to identify relevant instruments.
28. Having identified covariates for the second-stage (in 7 above) and instruments for the first-stage (in 8 above), re-estimate the IV specification equation using these two sets of variables. If the endogeneity test suggests that a variable (eg own programme expenditure in the outcome equation) is clearly not endogenous then re-estimate using OLS. If this re-estimation produces an acceptable result, the resulting elasticity shown in Table A1 has a 'B' in the next column.
29. If the above re-estimation approach produces a result which does not pass tests/have coefficients in line with priors, re-estimate the equation having adjusted the specification as suggested by the initial result (for example, if the result fails the misspecification test try adding the squared value of one of the regressors to the specification). If this re-estimation produces an acceptable result, the resulting elasticity shown in Table A1 has a 'C' in the next column.
30. If all of the above approaches fail to produce an acceptable result, consider excluding PCTs with extreme values of expenditure per person. Only explore this option for programmes with small amounts of expenditure and/or mortality. If this re-estimation approach produces an acceptable result, the resulting elasticity shown in Table A1 has a 'D' in the next column.

Results for 2004/05: elasticities from preferred specifications

31. The estimation strategy outlined above generated the outcome and expenditure elasticities for 2004/05 shown in Table A1.

Results for 2004/05: full IV/OLS result for preferred specifications

32. The full result [IV (second-stage) or OLS] associated with each elasticity reported in Table A1 can be found in Table A4 (for the outcome equations) and Table A5 (for the expenditure equations) in the appendix.

Results for 2004/05: estimation path to preferred specifications

33. The full estimation path for each result (starting with the re-estimation of the 2005/06 specification with updated data) can be found in Table A6 (for the outcome equations) and Table A7 (for the expenditure equations) in the appendix.

Table A1 Outcome and expenditure elasticities for 2004/05, 2005/06, 2006/07, 2007/08, 2008/09 and 2009/10

PBC #	PBC description	for 2009/10				for 2008/09				for 2007/08				for 2006/07				for 2005/06				for 2004/05				for 2003/04			
		Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P	Outcome elasticity	Re-est. P	Spend elasticity	Re-est. P
1	Infectious diseases	-0.310*	A	0.968***	--	-0.549***	A	147***	--	-0.660**	A	1387***	--	-0.608	A	105***	A	-0.432	--	1205***	--	-0.100	A	0.932***	A				
2	Cancers and tumours	-0.345***	--	0.502**	A	-0.287***	--	0.784**	--	-0.273***	--	1626***	A	-0.239***	A	1219***	--	-0.159*	A	1592***	A	-0.224**	--	1259***	--				
3	Diseases of the blood	n/a		1060***	B	n/a		0.995***	--	n/a		1374***	--	n/a		1037***	--	n/a		1486***	--	n/a		0.952***	A				
4	Endocrine, nutritional, metabolic	-1075**	A	0.708***	--	-1607**	--	0.498**	A	-1491	D	0.455***	--	-1464	A	0.630***	A	-1035	--	0.663***	--	-1843	A	0.573***	A				
5	Mental health disorders	n/a		0.899***	--	n/a		0.995***	--	n/a		1103***	--	n/a		1143***	--	n/a		0.991**	--	n/a		0.999***	--				
6	Learning disability	n/a		0.647**	B	n/a		0.329	--	n/a		0.386	--	n/a		0.410	B	n/a		0.449*	D	n/a		0.446*	--				
7	Neurological problems	-1357	C	0.850***	--	-0.304	C	0.897***	--	-0.237*	B	0.733***	A	-0.869*	D	0.382*	A	-0.325	A	1220***	--	-0.968**	A	0.929***	--				
8	Vision problems	n/a		0.934***	A	n/a		0.701**	--	n/a		1106***	C	n/a		0.931***	--	n/a		1127***	--	n/a		1350***	--				
9	Hearing problems	n/a		1273***	C	n/a		1637***	--	n/a		0.951*	A	n/a		0.989**	--	n/a		0.762**	--	n/a		0.526	C				
10	Circulatory problems	-1842***	--	0.494*	--	-1384***	--	1784***	A	-1315***	A	1614***	--	-1404***	--	1578***	--	-1637***	A	1477***	--	-1375***	A	1652***	--				
11	Respiratory problems	-2.103***	B	0.576***	--	-1671**	--	0.752**	--	-1564***	A	1555***	A	-2.281***	--	1287***	--	-2.217***	A	1225***	A	-2.494***	A	1253***	--				
12	Dental problems	n/a		0.765***	B	n/a		0.428**	B	n/a		0.420***	D	n/a		0.835**	C	n/a		See text	n/a	n/a		See text	n/a				
13	Gastro-intestinal problems	-1989*	A	0.387*	--	-1146**	A	0.520*	--	-0.837**	--	1490***	A	-1255**	--	1014***	A	-1014*	--	1076***	--	-1253***	--	0.928***	--				
14	Skin problems	n/a		0.890***	D	n/a		0.907***	--	n/a		0.787***	--	n/a		0.701**	A	n/a		0.840***	A	n/a		0.595***	A				
15	Musculo-skeletal problems	n/a		0.295	B	n/a		0.738***	C	n/a		0.733***	--	n/a		0.628**	A	n/a		0.935***	--	n/a		0.567***	--				
16	Trauma and injuries	0	n/a	1090***	--	0	n/a	1344***	--	-0.638	n/a	1328***	--	0	n/a	0.705***	--	Tbc		0.897***	A	Tbc		0.576**	A				
17	Genito-urinary problems	-2.997	B	0.878***	--	-0.024	C	0.733***	--	-1977	C	1015***	A	-0.588	D	0.988***	A	-0.869*	A	1079***	--	-0.931*	--	0.716***	A				
18	Maternity and reproductive health	-0.166*	B	0.653***	--	-0.030	A	0.963***	--	-0.057	--	0.563**	--	-0.085	C	0.614**	--	-0.056	B	0.865***	--	-0.121	--	0.678***	A				
19	Neonates																												
20	Poisoning and adverse events	n/a		0.658**	--	n/a		2.102***	--	n/a		1674***	A	n/a		1107***	--	n/a		1735***	--	n/a		1674***	--				
21	Healthy individuals	n/a		1246**	--	n/a		1049	--	n/a		1296**	C	n/a		0.709	B	n/a		0.507	B	n/a		0.709*	A				
22	Social care needs	n/a		0.844	B	n/a		1192*	--	n/a		1669**	C	n/a		1702***	--	n/a		1069*	--	n/a		1313**	--				
23	Other (includes GMS/FMS)	n/a		0.564***	B	n/a		0.338***	--	n/a		0.553***	--	n/a		0.447***	A	n/a		0.532***	--	n/a		0.337***	--				

Notes: (i) see pp3-4 of text for the meaning of the symbols in 're-estimation' columns;

(ii) the 're-estimation' columns for 2009/10 refer to a comparison of the preferred specification for 2009/10 at LA level with the preferred specification for 2008/09 at PCT level.

Part A Overview of results by PBC

Infectious diseases

34. Outcome: Re-estimation of the 2005/06 specification using updated data reveals a weak instrument set (Table A6). We dropped the insignificant regressor, and examined whether any additional regressor wanted to enter the specification. The 'white ethnic group' variable wanted to be included (see Table A6) but, with this specification, spend is not endogenous so we prefer the OLS version (see Table A4 and A6). This version excludes the 4 outlier PCTs as discussed in the paragraph below but their inclusion here has very little impact on the result. We tried re-deriving the specification but this proved unsuccessful.

35. Expenditure: Re-estimation of the 2005/06 specification using updated data generates a reasonable result (see Table A7) but fails the reset test. We tried investigating whether an additional regressor wanted to enter the specification but nothing proved successful. Investigation of the expenditure data revealed 4 very large spending PCTs (£87, £93, £139, and £143 per person compared with the fifth largest spending PCT (£63 per person)). Re-estimation of the 2005/06 specification without these four outliers resolves the reset test issue (Table A5 and A7).

Cancer and tumours

36. Outcome: Re-estimation of the 2005/06 specification with updated data reveals an acceptable result (Table A4 and Table A6).

37. Expenditure: Re-estimation of the 2005/06 specification with updated data generates an acceptable result (Table A5 and Table A7).

Blood disorders

38. Expenditure: Re-estimation of the 2005/06 specification reveals that two of the three regressors are insignificant so we dropped the 'lone parent' variable and examined whether any of the other available needs indicators wanted to be added to the specification. The addition of the 'owner occupied' variable generates the result shown in Table A5 and Table A7.

Endocrine, nutritional and metabolic

39. Outcome: Re-estimation of the 2005/06 specification using updated data generates an unacceptable result with weak instruments and a failed reset test (see Table A6). Using the usual pool of needs indicators, we found that the addition of the 'need squared' term as a regressor resolves both the weak instrument issue and the reset test issue (see Table A4 and A6). As was the case for 2005/06, we again excluded those LAs with expenditure beyond the 5th and 95th percentiles.

40. Expenditure: Two of the three regressors in the 2005/06 specification are insignificant (see Table A7) but the addition of the 'white ethnic group' variable resolves this issue (Table A5 and Table A7).

Mental health disorders

41. Expenditure: The 2005/06 specification generates an acceptable result (Table A5 and Table A7).

Learning disability

42. Expenditure: The 2005/06 specification generates an acceptable result (Table A5 and A7).

Neurological problems

43. Outcome: The 2005/06 specification (excluding those LAs with expenditure per head outside the 5th and 95th percentiles) generates an OK result but the two unpaid carer variables are insignificant (Table A6). If we drop these and examine whether any other regressor wants to be included in the specification then we get the result shown in both Tables A4 and A6.

44. Expenditure: The 2005/06 specification generates the acceptable result shown in Table A5 and Table A7.

Problems of vision

45. Expenditure: The 2005/06 specification generates an acceptable result (Table A5 and Table A7).

Problems of hearing

46. Expenditure: The 2005/06 specification generates a poor result with no significant regressors (see Table A7). Re-derivation generates the result shown in Table A7 where 'other need' has a significant positive coefficient and is not endogenous. The addition of the 'lone parent' variable removes the significance of 'other need' but OLS estimation of the same specification re-instates the positive significance of 'other need'. We therefore prefer the IV specification (see Table A5 and Table A7).

Circulatory problems

47. Outcome: The 2005/06 specification fails the valid instrument test (Table A6). Dropping the invalid instrument and re-estimating generates the result shown in Tables A4 and A6.

48. Expenditure: The 2005/06 specification generates an acceptable result (Table A5 and Table A7).

Respiratory problems

49. Outcome: The 2005/06 specification generates an acceptable result (Table A6) but this can be re-estimated without the insignificant 'need squared' variable (see Tables A4 and A6).

50. Expenditure: The 2005/06 specification generates an acceptable result (Table A5 and Table A7).

Dental problems

51. Expenditure: As Table A7 shows, the 2005/06 specification generates a poor result with a significant positive coefficient on 'other need' (as was the case for 2005/6, this excludes LAs spending outside the 5th and 95th percentiles). Re-derivation of an IV specification (with the same sample restrictions) still generates a significant coefficient on 'other need' but this variable is not endogenous. Re-estimation of this specification using OLS still generates a significant positive

coefficient on 'other need' (see Table A7) and re-estimation without any sample restrictions suffers from the same problem (again, see Table A7).

In the absence of a preferred specification, we might want to impute the value for the coefficient on budget using, say, either the most recent year's value or the average of all coefficients on budget over the estimation period.

Gastro-intestinal problems

52. Outcome: The 2005/06 specification produces an acceptable result (see Table A4 and Table A6). [Note that if we add a second instrument (eg IMD2007) then the resulting specification passes all tests and the coefficient on expenditure is -1.369***.]

53. Expenditure: The 2005/06 specification generates an acceptable result (Table A5 and Table A7) even though the 'other need' variable is only endogenous at the 25% level. [Note that if we add a second instrument (eg lone parents) then the resulting specification passes all tests and the coefficient on budget is 0.999***.]

Skin problems

54. Expenditure: The 2005/06 specification generates a significant positive coefficient on 'other need' (Table A7). Using the usual pool of available needs indicators, we found that the 'working in agriculture' variable is almost significant at the 10% level if added to the specification, and this specification generates an insignificant coefficient on 'other need' (see Tables A5 and A7).

Musculo-Skeletal system

55. Expenditure: The 2005/06 specification generates an acceptable (see Table A5 and Table A7).

Trauma and injuries

56. Outcome: Awaiting femur fracture and skull fracture SMRs from HSCIC (now NHS Digital).

57. Expenditure: The 2005/06 specification generates an acceptable result (Table A7) but this can be improved upon if we delete the insignificant 'working in agriculture' variable and re-estimate (see Table A5 and Table A7).

Genito-urinary system

58. Outcome: The 2005/06 specification contains a couple of insignificant regressors (Table A6) and if these are dropped and the specification re-estimated then we obtain the result shown in Tables A4 and A6. As was the case for 2005/06, we again excluded those LAs with expenditure beyond the 5th and 95th percentiles.

59. Expenditure: The 2005/06 specification fails the reset test (Table A7) but the addition of the squared needs indicator ('long-term unemployed') generates an acceptable result (Table A5 and Table A7).

Maternity/Neonates

60. Outcome: The 2005/06 specification generates an acceptable result (see Table A4 and Table A6).

61. Expenditure: The 2005/06 specification fails the reset test (Table A7) but the addition of the 'lone pensioner' variable (from the usual pool of available variables) generates an acceptable result (see Table A5 and Table A7).

Poisoning

62. Expenditure: The 2005/06 specification generates an acceptable result (Table A5 and Table A7).

Healthy Individuals

63. Expenditure: The 2005/06 specification generates a reasonable result but the 'unpaid carers' variable is insignificant (Table A7). Re-estimation without this variable generated another insignificant regressor ('born outside the EU') and, if both of these variables are omitted, then we obtain the result shown in Table A7. 'Other need' is not endogenous so we re-estimated using OLS (see Table A5 and Table A7).

Social Care

64. Expenditure: The 2005/06 specification generates an OK result but there is little evidence to suggest that the 'other need' variable is endogenous (Table A7). Hence we re-estimate using OLS and this result is shown in Tables A5 and A7. [Note that the sample restriction to LAs with expenditure per head of between £15 and £75 is the same as that employed for 2005/06. This is necessary because there is a large number of 'outliers'].

GMS/PMS

65. Expenditure: The 2005/06 specification generates an acceptable result (see Table A5 and Table A7).

All PBCs: Comparing specifications for 2004/05 and 2005/06

66. Table A2 summarises whether the preferred specification for each equation is the same as for the previous year ('pass') or, if not, why the previous year's specification is not suitable. For example, this might be because the previous specification does not 'pass' the appropriate statistical tests when estimated on updated data. It could also be because the estimated coefficients are incompatible with our prior beliefs about their sign and significance. For example, one of our priors is that, for the outcome equation, health care expenditure should not have a negative marginal effect on mortality and another is that, in the expenditure equation, budget should have a positive marginal effect on PBC expenditure. In a small number of cases, the previous specification might 'fail' on both statistical tests and on priors.

67. Finally, Table A3 reports the number times where the preferred specification for 2004/05 is OLS and this is the same/similar specification as was preferred for the previous year (i.e., we do not re-derive the OLS specification).

Table A2 Nature of failure of previous year's specification when applied to the following year's data

PBC #	PBC Title	2009/10 Outcome	2009/10 Expenditure	2008/09 Outcome	2008/09 Expenditure	2007/08 Outcome	2007/08 Expenditure	2006/07 Outcome	2006/07 Expenditure	2005/06 Outcome	2005/06 Expenditure	2004/05 Outcome	2004/05 Expenditure	2003/04 Outcome	2003/04 Expenditure
1	Infectious diseases	Tests		Tests		Tests		Tests	Tests			Tests	Tests		
2	Cancers and tumours		Prior (A)				Prior (A)	Tests		Tests	Tests				
3	Diseases of the blood	n/a	Prior (A)	n/a		n/a		n/a		n/a		n/a	Prior (C)		
4	Endocrine, nutritional, metabolic	Tests			Prior (A)	Tests, prior		Tests	Prior (C)			Tests	Prior (C)		
5	Mental health disorders	n/a													
6	Learning disability	n/a	Tests	n/a		n/a		n/a	Test, prior(A, C)	n/a	Prior (A)	n/a			
7	Neurological problems	Prior		Tests		Prior	Tests	Tests, prior	Test, prior(C)	Tests					
8	Vision problems	n/a	Priors (A, C)	n/a		n/a	Tests	n/a		n/a		n/a			
9	Hearing problems	n/a	Priors (A, C)	n/a		n/a	Prior [B]	n/a		n/a		n/a	Prior (A, C)		
10	Circulatory problems				Prior (A)	Tests				Tests		Tests			
11	Respiratory problems	Tests				Tests	Prior (A)			Tests	Tests				
12	Dental problems	n/a	Tests	n/a	Test, prior (B, C)	n/a	Test, prior [B]	n/a	Prior (C)	n/a	Test, prior(B)	n/a	n/a		
13	Gastro-intestinal problems	Tests					Prior (A)		Tests						
14	Skin problems	n/a	Tests	n/a		n/a		n/a	Prior (C)	n/a	Prior (C)	n/a	Prior(B)		
15	Musculo-skeletal problems	n/a	Prior (A)	n/a	Prior (A)	n/a		n/a	Prior (B)	n/a		n/a			
16	Trauma and injuries	n/a		n/a		n/a		n/a		n/a	Tests	n/a			
17	Genito-urinary problems	Prior		Prior		Prior	Prior [C]	Tests	Tests				Tests		
18	Maternity and reproductive health	Tests		Prior				Prior		Tests			Tests		
19	Neonates														
20	Poisoning and adverse events	n/a		n/a		n/a	Prior (A)	n/a		n/a		n/a			
21	Healthy individuals	n/a		n/a		n/a	Prior [A, C]	n/a	Prior(A, B, C)	n/a	Prior (B, C)	n/a			
22	Social care needs	n/a	Prior (C)	n/a		n/a	Prior [C]	n/a		n/a		n/a			
23	Other (includes GMS/PMS)	n/a	Priors (A, C)	n/a		n/a		n/a	Tests	n/a		n/a			
Totals	Pass (= blank cell)	n=2	n=12	n=5	n=13	n=3	n=11	n=3	n=11	n=4	n=15	n=6	n=14		
	Tests	n=5	n=3	n=2	n=0	n=3	n=2	n=4	n=4	n=5	n=3	n=3	n=3		
	Prior (negative coefficient on expenditure)	n=2		n=2		n=2		n=1		n=0		n=0			
	Tests and priors	n=0	n=0		n=1	n=1	n=1	n=1	n=2	n=0	n=1	n=0	n=0		
	Prior (A: 'significant', +ve coefficient on budget)		n=3		n=3		n=4				n=1		n=0		
	Prior (B: no significant +ve coefficient on o/need)		n=0				n=1		n=1		n=0		n=1		
	Prior (C: other coefficients significant)		n=1				n=2		n=3		n=1		n=2		
	Priors (B, C)		n=0				n=0		n=0		n=1		n=0		
	Priors (A, B, C)		n=0				n=0		n=1		n=0		n=0		
	Priors (A, C)		n=3				n=1		n=1		n=0		n=1		

Notes: (i) here, 'previous year' relates to the next year temporally (ie we are working backwards); and

(ii) a 'pass' is recorded if the only change is to drop an insignificant regressor (will be recorded as an 'A' in Table 1) and/or if an IV specification is re-estimated using OLS.

Table A3 OLS specification for previous year and current year

Number of times preferred specification is OLS and the same/similar OLS specification as in the previous year		2008/09	2007/08	2006/07	2005/06	2004/05	2003/04
Outcome equation	(maximum n=9)	n=1	n=1	n=0	n=1	n=2	
Expenditure equation	(maximum n=22)	n=11	n=12	n=12	n=12	n=12	

APPENDIX

Part B Preferred specifications for outcome and expenditure models for 2004/05

In this section, Tables A4 and A5 provide details of our preferred specification for each outcome and expenditure model by PBC for 2004/05.

Table A4 Preferred outcome specifications for 2004/05

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	PBC 1	PBC 2	PBC 4	PBC 7	PBC 10	PBC 11	PBC 13	PBC 17	PBC 1819
	infectious	cancer	endocrine	neurological	circulatory	respiratory	gastro	genito-	mat/neonates
	2004/5 spend	2004/5 spend	2004/5 spend	2004/5 spend	2004/5 spend	2004/5 spend	2004/5 spend	2004/5 spend	2004/5 spend
	SYLLR 2004/5/6	SYLLR 2004/5/6	SYLLR 2004/5/6	SYLLR 2004/5/6	SYLLR 2004/5/6	SYLLR 2004/5/6	SYLLR 2004/5/6	SYLLR 2004/5/6	SYLLR 2004/5/6
	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model
	instrument n/a	instrument spend	instrument n/a	instrument spend					
	weighted	weighted	weighted	weighted	weighted	weighted	weighted	weighted	weighted
	OLS	IV second stage	OLS	OLS					
	GMM2S	GMM2S	GMM2S	GMM2S	GMM2S	GMM2S	GMM2S	GMM2S	GMM2S
	LA-level	LA-level	LA-level	LA-level	LA-level	LA-level	LA-level	LA-level	LA-level
	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality
	actual census 04	actual census 04	actual census 04	actual census 04	actual census 04	actual census 04	actual census 04	actual census 04	actual census 04
VARIABLES	05/06 revised	05/06 specification	05/06 revised	05/06 revised	05/06 revised	05/06 revised	05/06 specification	05/06 revised	05/06 specification
ILAhivneedph	0.112** [0.054]								
ILAIMd_2007exexpobook	0.282*** [0.088]		0.667*** [0.185]	0.503*** [0.121]					0.235*** [0.072]
LOWNOCC04	-0.414* [0.242]								
LWHITEEG04	-0.941*** [0.195]							-1.964*** [0.340]	
ILAg1_45	-0.100 [0.107]								
ILAg2_45OHP		-0.224** [0.111]							
ILANeedCARAN45		0.778*** [0.082]			1.223*** [0.352]	4.895*** [1.041]	3.466*** [0.452]		
ILAg4_45OHP			-1.843 [1.126]						
ILAdiaprev0405			0.855*** [0.297]						
ILANeedCARAN452			2.426 [1.905]						
ILAg7_45OHP				-0.968** [0.484]					
LWORKAGRI04				0.126** [0.057]					

ILAg10_45netpopheadOHP					-1.375***				
					[0.205]				
LPERMSICK04					0.518***				
					[0.104]				
ILAg11_45OHP						-2.494***			
						[0.832]			
ILAg13_45netpopheadOHP							-1.253***		
							[0.437]		
ILAg17_45netpopheadOHP								-0.931*	
								[0.550]	
LNQUAL17404								2.156***	0.638***
								[0.477]	[0.166]
ILAg1819_45OHP									-0.121
									[0.101]
LLONEPENH04									-0.409**
									[0.206]
LBORNEXEU04									0.070*
									[0.040]
Constant	1.106***	6.008***	8.364**	4.082**	12.804***	13.346***	8.469***	5.829**	1.210*
	[0.344]	[0.481]	[3.974]	[1.722]	[1.042]	[3.439]	[1.872]	[2.597]	[0.631]
Observations	145	151	136	137	151	151	151	137	151
R-squared	0.565							0.211	0.457
Ramsey reset F statistic	0.698							0.803	1.023
Probability > F	0.555							0.494	0.384
Endogeneity test statistic		2.886	3.349	2.863	30.641	26.954	6.925		
Endogeneity p-value		0.089	0.067	0.091	0.000	0.000	0.009		
Hansen-Sargan test statistic		0.297		0.880					
Hansen-Sargan p-value		0.586		0.348					
Kleibergen-Paap LM test statistic		14.712	7.045	16.830	21.333	7.554	16.801		
Kleibergen-Paap p-value		0.001	0.008	0.000	0.000	0.006	0.000		
Kleibergen-Paap F statistic		9.441	10.808	14.107	67.065	13.553	33.424		
Pesaran-Taylor reset statistic		2.454	2.713	2.393	0.150	0.551	0.534		
Pesaran-Taylor p-value		0.293	0.100	0.122	0.699	0.458	0.465		

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table A5 Preferred expenditure specifications for 2004/05

	(1) PBC 1 infectious 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 revised	(2) PBC 2 cancer 2004/5 spend SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 specification	(3) PBC 3 blood 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 revised	(4) PBC 4 endocrine 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 revised	(5) PBC 5 mental health 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 specification	(6) PBC 6 LDisability 2004/05 spend SYLLR 2004/05/06 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 5/6 specification	(7) PBC 7 neurological 2004/05 spend SYLLR 2004/05/06 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 5/6 specification	(8) PBC 8 vision 2004/5 spend SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 specification	(9) PBC 9 hearing 2004/5 spend SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 04 re-derived+	(10) PBC 10 circulatory 2004/5 spend SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 specification
ILAgall_45netpopheadOHP	0.932*** [0.210]	1.259*** [0.278]	0.952*** [0.355]	0.573*** [0.111]	0.999*** [0.170]	0.446* [0.260]	0.929*** [0.212]	1.350*** [0.319]	0.526 [0.412]	1.652*** [0.247]
ILAhivneedph	0.252*** [0.028]									
ISYLLRacExlandP456	-0.125 [0.158]									
ILAhivneedph2	0.092*** [0.024]									
ISYLLRacExCancer456		-1.622*** [0.495]								
LPROFOCCU04		-0.907*** [0.275]								
LOWNOCC04		-0.578** [0.281]	-0.679*** [0.180]							
ISYLLRallcause456			-0.027 [0.203]		-0.108 [0.154]	-0.154 [0.211]		-0.825*** [0.293]	0.870 [0.540]	
LNQUAL17404				0.172** [0.068]				0.635*** [0.117]		0.667*** [0.099]
LWHITEEG04				-0.215*** [0.082]						
ISYLLRacExDIA456				-0.103 [0.106]						
ILAmhneedindexpp					0.356* [0.182]					
LPOPPUCAR04					-0.743*** [0.099]				1.026*** [0.325]	
ILAneedCARAN452						3.141** [1.563]				
ILAepiprev0405							0.196* [0.106]			
ISYLLRacExEPI456							-0.306** [0.136]			
LLONPENH04									-0.458 [0.289]	
LPC74LTUN04									-0.239*	

LLONEPARH04									[0.142]	
									-0.006	
ISYLLRacExCirc456									[0.313]	-1.390***
Constant	-2.947***	3.265*	-4.090**	0.224	-3.165*	1.448	-0.206	-0.380	-6.905*	2.137**
	[1.015]	[1.973]	[1.814]	[0.792]	[1.786]	[1.613]	[1.367]	[1.119]	[3.779]	[1.064]
Observations	145	151	151	151	151	137	151	151	151	151
R-squared	0.584		0.371	0.369	0.667	0.073	0.200			
Ramsey reset F statistic	0.330		0.444	1.478	1.235	0.612	1.654			
Probability > F	0.803		0.722	0.223	0.299	0.609	0.180			
Endogeneity test statistic		13.951						4.380	0.049	18.772
Endogeneity p-value		0.000						0.036	0.825	0.000
Kleibergen-Paap LM test statistic		14.760						35.712	29.992	25.947
Kleibergen-Paap p-value		0.000						0.000	0.000	0.000
Kleibergen-Paap F statistic		14.608						41.912	40.253	23.031
Pesaran-Taylor reset statistic		0.442						0.123	0.044	0.024
Pesaran-Taylor p-value		0.506						0.726	0.835	0.877
Hansen-Sargan test statistic								2.023	1.404	1.474
Hansen-Sargan p-value								0.155	0.236	0.225

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table A5 continued Preferred expenditure specifications for 2004/05

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PBC 11	PBC 13	PBC 14	PBC 15	PBC 16	PBC 17	PBC 1819	PBC 20
	respiratory	gastro	skin problems	musculo-skeletal	trauma	genito-	mat/neonates	poisoning
	2004/5 spend	2004/5 spend	2004/05 spend	2004/05 spend	2004/5 spend	2004/5 spend	2004/05 spend	2004/5 spend
	SYLLR 2004/5/6	SYLLR 2004/5/6	SYLLR 2004/5/6	SYLLR 2004/5/6	SYLLR 2004/5/6	SYLLR 2004/5/6	SYLLR 2004/5/6	SYLLR 2004/5/6
	spend model	spend model	spend model	spend model	spend model	spend model	spend model	spend model
	instrument o/need	instrument o/need	instrument n/a	instrument n/a	instrument n/a	instrument n/a	o/need exogenous	instrument o/need
	weighted	weighted	weighted	weighted	weighted	weighted	weighted	weighted
	IV second stage	IV second stage	OLS	OLS	OLS	OLS	OLS	IV second stage
	GMM2S	GMM2S						GMM2S
	LA-level	LA-level	LA-level	LA-level	LA-level	LA-level	LA-level	LA-level
	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality
	actual census 04	actual census 04	actual census 04	actual census 04	actual census 04	actual census 04	actual census 04	actual census 04
VARIABLES	05/06 specification	05/06 specification	05/06 specification	05/06 specification	05/06 revised	05/06 revised	05/06 revised	05/06 specification
ISYLLRacExResp456	-0.377*							
	[0.205]							
ILAgall_45netpopheadOHP	1.253***	0.928***	0.595***	0.567***	0.576**	0.716***	0.678***	1.674***
	[0.186]	[0.167]	[0.203]	[0.164]	[0.235]	[0.242]	[0.156]	[0.297]
LNQUAL17404	0.430***	0.467***	0.176*					0.706***
	[0.080]	[0.066]	[0.101]					[0.142]
ISYLLRacExGast456		-0.399**						
		[0.203]						
ISYLLRallcause456			0.114	-0.023	-0.244		-0.025	-1.414***
			[0.175]	[0.158]	[0.150]		[0.127]	[0.295]
LWORKAGRI04			-0.032					
			[0.020]					
LPC74LTUN04				-0.203***		1.522**		
				[0.063]		[0.699]		
LPROFOCCU04				-0.390***				
				[0.097]				
ILAneedCARAN45					0.618**			
					[0.278]			
ISYLLRacExrenal456						-0.160		
						[0.188]		
LPC74LTUN045Q						0.154*		
						[0.078]		
ILAmatneedindexpp							0.600***	
							[0.134]	
LLONEPENH04							-0.276*	
							[0.144]	
Constant	-1.899**	0.749	-1.639	-1.025	1.679	3.734	-0.983	0.219
	[0.802]	[0.746]	[1.055]	[1.468]	[1.957]	[2.268]	[0.998]	[1.395]
Observations	151	151	151	151	151	151	151	151
Endogeneity test statistic	5.586	1.528						12.795
Endogeneity p-value	0.018	0.216						0.000
Kleibergen-Paap LM test statistic	28.181	33.441						33.481
Kleibergen-Paap p-value	0.000	0.000						0.000

Kleibergen-Paap F statistic	58.442	112.795					40.539
Pesaran-Taylor reset statistic	0.021	0.845					1.118
Pesaran-Taylor p-value	0.885	0.358					0.290
Hansen-Sargan test statistic							1.316
Hansen-Sargan p-value							0.251
R-squared			0.362	0.249	0.363	0.366	0.523
Ramsey reset F statistic			1.547	1.891	0.676	1.843	1.850
Probability > F			0.205	0.134	0.568	0.142	0.141

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table A5 continued Preferred expenditure specifications for 2004/05

	(1)	(2)	(3)
	PBC 21	PBC 22	PBC 23a
	HI	social care	GMS
	2004/05 spend	2004/05 spend	2004/5 spend
	SYLLR 2004/05/06	SYLLR 2004/05/06	SYLLR 2004/5/6
	spend model	spend model	spend model
	o/need exogenous	o/need exogenous	instrument n/a
	weighted	weighted	weighted
	OLS	OLS	OLS
	LA-level	LA-level	LA-level
	actual mortality	actual mortality	actual mortality
	actual census 04	actual census 04	actual census 04
VARIABLES	05/06 revised OLS	05/06 OLS	05/06 specification
lAgall_45netpopheadOHP	0.709*	1.313**	0.337***
	[0.411]	[0.511]	[0.096]
LWORKAGRI04	-0.047		0.034***
	[0.036]		[0.012]
LWHITEEG04			-0.170***
			[0.046]
lSYLLRallcause456	0.323	-0.940**	0.071
	[0.277]	[0.427]	[0.062]
Constant	-4.176**	-0.206	2.166***
	[1.881]	[3.050]	[0.487]
Observations	151	98	146
R-squared	0.174	0.076	0.259
Ramsey reset F statistic	1.780	1.085	1.314
Probability > F	0.154	0.360	0.272

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

APPENDIX

Part C Estimation path to preferred specifications for outcome and expenditure models for 2004/05

In this section, Tables A6 and A7 provide details of the estimation path to our preferred specifications for each outcome and expenditure model by PBC for 2004/05. For each PBC, we first estimate the model for 2004/05 using our preferred specification for 2005/06. If this specification fails to meet either the necessary statistical tests or our prior beliefs about the sign/size/significance of coefficients, then the specification is adjusted in line with our estimation strategy outlined on pp2-3 and the model is re-estimated. This process continues until we identify a specification that meets our priors and passes the relevant statistical tests. The final, preferred specification for each PBC for 2004/05 is also shown here, along with the results associated with the estimation of selected intermediate specifications.

Table A6 Estimation path to preferred outcome specifications for 2004/05

	(1) PBC 1 infectious 2004/5 spend SYLLR 2004/5/6 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 specification	(2) PBC 1 infectious 2004/5 spend SYLLR 2004/5/6 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 revised	(3) PBC 1 infectious 2004/5 spend SYLLR 2004/5/6 outcome model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 revisedOLS	(4) PBC 2 cancer 2004/5 spend SYLLR 2004/5/6 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 specification	(5) PBC 4 endocrine 2004/5 spend SYLLR 2004/5/6 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 specification	(6) PBC 4 endocrine 2004/5 spend SYLLR 2004/5/6 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 revised	(7) PBC 7 neurological 2004/5 spend SYLLR 2004/5/6 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 specification	(8) PBC 7 neurological 2004/5 spend SYLLR 2004/5/6 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 revised	(9) PBC 10 circulatory 2004/5 spend SYLLR 2004/5/6 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 specification	(10) PBC 10 circulatory 2004/5 spend SYLLR 2004/5/6 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 revised
ILAg1_45	-0.973 [0.884]	-0.077 [0.248]	-0.100 [0.107]							
ILAhivneedph	0.578** [0.270]	0.163** [0.078]	0.112** [0.054]							
ILAhivneedph2	0.216 [0.153]									
ILAIMd_2007exexpobook	0.550*** [0.185]	0.356*** [0.102]	0.282*** [0.088]		0.774*** [0.267]	0.667*** [0.185]	0.295*** [0.089]	0.503*** [0.121]		
LWHITEG04		-0.955*** [0.195]	-0.941*** [0.195]							
LOWNOCC04			-0.414* [0.242]							
ILAg2_45OHP				-0.224** [0.111]						
ILANeedCARAN45				0.778*** [0.082]					1.207*** [0.356]	1.223*** [0.352]
ILAg4_45OHP					-2.529	-1.843				

ILAdiaprev0405					[1.636] 0.845** [0.333]	[1.126] 0.855*** [0.297]				
ILAneedCARAN452						2.426 [1.905]				
ILAg7_45OHP							-0.536 [0.383]	-0.968** [0.484]		
LPOPPUCAR04							-6.237 [8.674]			
LPOPPUCAR04SQ							-1.507 [1.862]			
LWORKAGRI04								0.126** [0.057]		
ILAg10_45netpopheadOHP									-1.392*** [0.207]	-1.375*** [0.205]
LPERMSICK04									0.525*** [0.105]	0.518*** [0.104]
Constant	3.116 [2.047]	1.012* [0.548]	1.106*** [0.344]	6.008*** [0.481]	10.415* [5.545]	8.364** [3.974]	-3.786 [10.271]	4.082** [1.722]	12.910*** [1.053]	12.804*** [1.042]
Observations	149	149	145	151	136	136	137	137	151	151
Endogeneity test statistic	1.159	0.093		2.886	3.756	3.349	1.012	2.863	26.339	30.641
Endogeneity p-value	0.282	0.761		0.089	0.053	0.067	0.315	0.091	0.000	0.000
Kleibergen-Paap LM test statistic	2.497	10.312		14.712	4.935	7.045	21.152	16.830	21.664	21.333
Kleibergen-Paap p-value	0.114	0.001		0.001	0.026	0.008	0.000	0.000	0.000	0.000
Kleibergen-Paap F statistic	2.750	13.118		9.441	6.708	10.808	19.040	14.107	33.911	67.065
Pesaran-Taylor reset statistic	1.065	0.337		2.280	4.506	2.713	1.601	2.393	0.139	0.150
Pesaran-Taylor p-value	0.302	0.561		0.320	0.034	0.100	0.206	0.122	0.709	0.699
Hansen-Sargan test statistic				0.297			0.448	0.880	4.367	
Hansen-Sargan p-value				0.586			0.503	0.348	0.037	
R-squared			0.565							
Ramsey reset F statistic			0.698							
Probability > F			0.555							

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table A6 continued Estimation path to preferred outcome specifications for 2004/05

	(1)	(2)	(3)	(4)	(5)	(6)
	PBC 11 respiratory 2004/5 spend	PBC 11 respiratory 2004/5 spend	PBC 13 gastro 2004/5 spend	PBC 17 genito- 2004/5 spend	PBC 17 genito- 2004/5 spend	PBC 1819 mat/neonates 2004/05 spend inf mort rate 2004/05/06 outcome model spend exogenous weighted OLS
VARIABLES	SYLLR 2004/5/6 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 specification	SYLLR 2004/5/6 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 revised	SYLLR 2004/5/6 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 specification	SYLLR 2004/5/6 outcome model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 specification	SYLLR 2004/5/6 outcome model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 revised	SYLLR 2004/5/6 outcome model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 specification
ILAg17_45netpopheadOHP				-0.782 [0.581]	-0.931* [0.550]	
LNQUAL17404				2.300*** [0.549]	2.156*** [0.477]	0.638*** [0.166]
LPOPPUCAR04				-0.384 [1.603]		
LOWNOCC04				0.570 [0.708]		
LWHITEEG04				-2.153*** [0.497]	-1.964*** [0.340]	
ILAg11_45OHP	-2.436*** [0.827]	-2.494*** [0.832]				
ILAg11_45OHP	4.801*** [1.035]	4.895*** [1.041]	3.466*** [0.452]			
ILAg11_45OHP	1.457 [1.254]					
ILAg13_45netpopheadOHP			-1.253*** [0.437]			
ILAg1819_45OHP						-0.121 [0.101]
LLONEPENH04						-0.409** [0.206]
LBORNEXEU04						0.070* [0.040]
ILAg11_45OHP						0.235*** [0.072]
Constant	13.082*** [3.420]	13.346*** [3.439]	8.469*** [1.872]	4.723 [4.890]	5.829** [2.597]	1.210* [0.631]
Observations	151	151	151	137	137	151
R-squared				0.214	0.211	0.457
Endogeneity test statistic	25.181	26.954	6.925			
Endogeneity p-value	0.000	0.000	0.009			
Kleibergen-Paap LM test statistic	7.565	7.554	16.801			
Kleibergen-Paap p-value	0.006	0.006	0.000			

Kleibergen-Paap F statistic	13.453	13.553	33.424			
Pesaran-Taylor reset statistic	0.879	0.551	0.534			
Pesaran-Taylor p-value	0.348	0.458	0.465			
Ramsey reset F statistic				0.995	0.803	1.023
Probability > F				0.397	0.494	0.384

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table A7 Estimation path to preferred expenditure specifications for 2004/05

	(1) PBC 1 infectious 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 specification	(2) PBC 1 infectious 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 revised	(3) PBC 2 cancer 2004/5 spend SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 specification	(4) PBC 3 blood 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 specification	(5) PBC 3 blood 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 revised	(6) PBC 4 endocrine 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 specification	(7) PBC 4 endocrine 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 revised	(8) PBC 5 mental health 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 specification	(9) PBC 6 LDisability 2004/05 spend SYLLR 2004/05/06 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 specification
ILAgall_45netpopheadOHP	1.106*** [0.265]	0.932*** [0.210]	1.259*** [0.278]	1.527*** [0.342]	0.952*** [0.355]	0.556*** [0.114]	0.573*** [0.111]	0.999*** [0.170]	0.446* [0.260]
ILAhivneedph	0.305*** [0.030]	0.252*** [0.028]							
ISYLLRacExlandP456	-0.252 [0.189]	-0.125 [0.158]							
ILAhivneedph2	0.139*** [0.028]	0.092*** [0.024]							
ISYLLRacExCancer456			-1.622*** [0.495]						
LPROFOCCU04			-0.907*** [0.275]						
LOWNOCC04			-0.578** [0.281]		-0.679*** [0.180]				
ISYLLRallcause456				-0.437 [0.350]	-0.027 [0.203]			-0.108 [0.154]	-0.154 [0.211]
LLONEPARH04				0.424 [0.278]					
LNQUAL17404						0.076 [0.064]	0.172** [0.068]		
ISYLLRacExDIA456						0.047 [0.109]	-0.103 [0.106]		
LWHITEEG04							-0.215*** [0.082]		
ILAmhneedindexpp								0.356* [0.182]	
LPOPPUCAR04								-0.743*** [0.099]	
ILAneedCARAN452									3.141** [1.563]
Constant	-3.412*** [1.159]	-2.947*** [1.015]	3.265* [1.973]	-4.206 [3.612]	-4.090** [1.814]	-0.679 [0.730]	0.224 [0.792]	-3.165* [1.786]	1.448 [1.613]
Observations	149	145	151	151	151	151	151	151	137
R-squared	0.701	0.584		0.324	0.371	0.324	0.369	0.667	0.073
Ramsey reset F statistic	6.381	0.330		1.723	0.444	0.073	1.478	1.235	0.612

Probability > F	0.000	0.803		0.165	0.722	0.974	0.223	0.299	0.609
Endogeneity test statistic			13.951						
Endogeneity p-value			0.000						
Kleibergen-Paap LM test statistic			14.760						
Kleibergen-Paap p-value			0.000						
Kleibergen-Paap F statistic			14.608						
Pesaran-Taylor reset statistic			0.442						
Pesaran-Taylor p-value			0.506						

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table A7 continued Estimation path to preferred expenditure specifications for 2004/05

	(1) PBC 7 neurological 2004/05 spend SYLLR 2004/05/06 spend model instrument n/a weighted OLS	(2) PBC 8 vision 2004/5 spend SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S	(3) PBC 9 hearing 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS	(4) PBC 9 hearing 2004/5 spend SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S	(5) PBC 9 hearing 2004/5 spend SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S	(6) PBC 10 circulatory 2004/5 spend SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S	(7) PBC 11 respiratory 2004/5 spend SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S	(8) PBC 12 dental 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS	(9) PBC 12 dental 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS	(10) PBC 12 dental 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS
VARIABLES	LA-level actual mortality actual census 04 05/06 specification	LA-level actual mortality actual census 04 05/06 specification	LA-level actual mortality actual census 04 05/06 specification	re-derived	re-derived+	specification	specification	specification	re-derived OLS	re-derived OLS+
ILAgall_45netpopheadOHP	0.929*** [0.212]	1.350*** [0.319]	0.291 [0.361]	0.529 [0.377]	0.526 [0.412]	1.652*** [0.247]	1.253*** [0.186]	0.848* [0.432]	0.846* [0.432]	1.092** [0.447]
ILAepiprev0405	0.196* [0.106]									
ISYLLRacExEPI456	-0.306** [0.136]									
ISYLLRallcause456		-0.825*** [0.293]	0.439 [0.321]	0.863** [0.375]	0.870 [0.540]			1.841*** [0.442]	1.839*** [0.438]	2.294*** [0.450]
LNQUAL17404		0.635*** [0.117]				0.667*** [0.099]	0.430*** [0.080]	-1.045*** [0.384]	-1.054*** [0.379]	-1.419*** [0.393]
LPROFOCCU04			-0.193 [0.202]							
LLONEPENH04				-0.458 [0.286]	-0.458 [0.289]					
LPOPPUCAR04				1.028*** [0.316]	1.026*** [0.325]			1.806*** [0.616]	1.854*** [0.570]	2.097*** [0.625]
LPC74LTUN04				-0.240* [0.129]	-0.239* [0.142]					
LLONEPARH04					-0.006 [0.313]					
ISYLLRacExCirc456						-1.390*** [0.283]				
ISYLLRacExResp456							-0.377* [0.205]			
LWORKAGRI04								0.124** [0.057]	0.129** [0.052]	0.149*** [0.052]
LWHITEEG04								0.062 [0.289]		
Constant	-0.206 [1.367]	-0.380 [1.119]	-3.208 [1.955]	-6.865** [3.164]	-6.905* [3.779]	2.137** [1.064]	-1.899** [0.802]	-11.441*** [2.568]	-11.302*** [2.620]	-15.634*** [2.564]
Observations	151	151	151	151	151	151	151	137	137	151
R-squared	0.200		0.156					0.327	0.327	0.381
Ramsey reset F statistic	1.654		0.917					1.816	1.877	0.673
Probability > F	0.180		0.434					0.148	0.137	0.570

Endogeneity test statistic	4.380	0.066	0.049	18.772	5.586
Endogeneity p-value	0.036	0.798	0.825	0.000	0.018
Hansen-Sargan test statistic	2.023	1.404	1.404	1.474	
Hansen-Sargan p-value	0.155	0.495	0.236	0.225	
Kleibergen-Paap LM test statistic	35.712	36.049	29.992	25.947	28.181
Kleibergen-Paap p-value	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F statistic	41.912	48.273	40.253	23.031	58.442
Pesaran-Taylor reset statistic	0.123	0.042	0.044	0.024	0.021
Pesaran-Taylor p-value	0.726	0.837	0.835	0.877	0.885

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table A7 continued Estimation path to preferred expenditure specifications for 2004/05

	(1) PBC 13 gastro 2004/5 spend	(2) PBC 14 skin problems 2004/05 spend	(3) PBC 14 skin problems 2004/05 spend	(4) PBC 15 musculo-skeletal 2004/05 spend	(5) PBC 16 trauma 2004/5 spend	(6) PBC 16 trauma 2004/5 spend	(7) PBC 17 genito- 2004/5 spend	(8) PBC 17 genito- 2004/5 spend	(9) PBC 1819 mat/neonates 2004/05 spend infant mort rate 2004/05/06 spend model	(10) PBC 1819 mat/neonates 2004/05 spend infant mort rate 2004/05/06 spend model
VARIABLES	SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 04 05/06 specification	SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 spedcification	SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 revised	SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 specification	SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 revised	SYLLR 2004/5/6 spend model o/need exogenous weighted OLS LA-level actual mortality actual census 04 05/06 specification	SYLLR 2004/5/6 spend model o/need exogenous weighted OLS LA-level actual mortality actual census 04 05/06 revised			
ISYLLRacExGast456	-0.399** [0.203]									
ILAgall_45netpopheadOHP	0.928*** [0.167]	0.581*** [0.210]	0.595*** [0.203]	0.567*** [0.164]	0.607** [0.237]	0.576** [0.235]	0.706*** [0.244]	0.716*** [0.242]	0.647*** [0.157]	0.678*** [0.156]
LNQUAL17404	0.467*** [0.066]	0.099 [0.091]	0.176* [0.101]							
ISYLLRallcause456		0.271* [0.157]	0.114 [0.175]	-0.023 [0.158]	-0.174 [0.152]	-0.244 [0.150]			-0.103 [0.126]	-0.025 [0.127]
LWORKAGRI04			-0.032 [0.020]		0.019 [0.015]					
LPC74LTUN04				-0.203*** [0.063]			0.159** [0.063]	1.522** [0.699]		
LPROFOCCU04				-0.390*** [0.097]						
ILAneedCARAN45					0.568** [0.283]	0.618** [0.278]				
ISYLLRacExrenal456							-0.158 [0.187]	-0.160 [0.188]		
LPC74LTUN04SQ								0.154* [0.078]		
ILAmatneedindexpp									0.774*** [0.103]	0.600*** [0.134]
LLONEPENH04										-0.276* [0.144]
Constant	0.749 [0.746]	-2.451** [0.956]	-1.639 [1.055]	-1.025 [1.468]	1.126 [2.003]	1.679 [1.957]	0.792 [1.649]	3.734 [2.268]	0.261 [0.744]	-0.983 [0.998]
Observations	151	151	151	151	151	151	151	151	151	151
R-squared		0.349	0.362	0.249	0.369	0.363	0.348	0.366	0.514	0.523
Endogeneity test statistic	1.528									
Endogeneity p-value	0.216									
Kleibergen-Paap LM test statistic	33.441									
Kleibergen-Paap p-value	0.000									

Kleibergen-Paap F statistic	112.795									
Pesaran-Taylor reset statistic	0.845									
Pesaran-Taylor p-value	0.358									
Ramsey reset F statistic		1.889	1.547	1.891	0.684	0.676	3.899	1.843	3.930	1.850
Probability > F		0.134	0.205	0.134	0.563	0.568	0.010	0.142	0.010	0.141

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Table A7 continued Estimation path to preferred expenditure specifications for 2004/05

	(1) PBC 20 poisoning 2004/5 spend SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 04	(2) PBC 21 HI 2004/5 spend SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 04	(3) PBC 21 HI 2004/5 spend SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 04	(4) PBC 21 HI 2004/05 spend SYLLR 2004/05/06 spend model o/need exogenous weighted OLS LA-level actual mortality actual census 04	(5) PBC 22 social care 2004/5 spend SYLLR 2004/5/6 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 04	(6) PBC 22 social care 2004/05 spend SYLLR 2004/05/06 spend model o/need exogenous weighted OLS LA-level actual mortality actual census 04 05/06 specification	(7) PBC 23a GMS 2004/5 spend SYLLR 2004/5/6 spend model instrument n/a weighted OLS LA-level actual mortality actual census 04 05/06 specification
VARIABLES	05/06 specification	05/06 specification	05/06 revised	05/06 revised OLS	05/06 specification	OLS	05/06 specification
ISYLLRallcause456	-1.414*** [0.295]	0.121 [0.352]	0.130 [0.364]	0.323 [0.277]	-1.086** [0.511]	-0.940** [0.427]	0.071 [0.062]
ILAgall_45netpopheadOHP	1.674*** [0.297]	0.834* [0.446]	0.909** [0.459]	0.709* [0.411]	1.590** [0.652]	1.313** [0.511]	0.337*** [0.096]
LPOPPUCAR04		-0.436 [0.411]					
LBORNEXEU04		-0.115* [0.063]					
LWORKAGRI04		-0.108** [0.043]	-0.069* [0.036]	-0.047 [0.036]			0.034*** [0.012]
LNQUAL17404	0.706*** [0.142]						
LWHITEEG04							-0.170*** [0.046]
Constant	0.219 [1.395]	-5.448** [2.439]	-4.514** [1.838]	-4.176** [1.881]	-1.294 [3.015]	-0.206 [3.050]	2.166*** [0.487]
Observations	151	151	151	151	98	98	146
R-squared				0.174		0.076	0.259
Endogeneity test statistic	12.795	0.441	0.443		0.764		
Endogeneity p-value	0.000	0.507	0.506		0.382		
Hansen-Sargan test statistic	1.316	0.711	2.613		4.636		
Hansen-Sargan p-value	0.251	0.871	0.455		0.200		
Kleibergen-Paap LM test statistic	33.481	34.535	22.946		25.180		
Kleibergen-Paap p-value	0.000	0.000	0.000		0.000		
Kleibergen-Paap F statistic	40.539	52.250	53.266		41.491		
Pesaran-Taylor reset statistic	1.118	1.647	1.330		0.076		
Pesaran-Taylor p-value	0.290	0.199	0.249		0.783		
Ramsey reset F statistic				1.780		1.085	1.314
Probability > F				0.154		0.360	0.272

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Appendix 2: Expected health opportunity costs in the NHS (2004/05 results)

Overview

68. In the second appendix results are presented that reflect the available data for 2004/05 expenditure (this forms Appendix 2.1). In Appendix 2.2, the results are also analysed in terms of how sensitive the results are to two key inputs: i) each of the estimated elasticities and ii) assumptions made in order to overcome data limitations for each PBC (only have mortality outcome data and for only a portion of PBCs). Finally, Appendix 2.3 briefly considers an update regarding data from ONS used to inform burden of disease.

Appendix 2.1 Results

69. Results are presented in two ways as the point estimate of the cost per QALY of marginal activity in the NHS, or alternatively expressed as the expected QALY health opportunity cost for £10,000,000 expenditure.

Table A8 Deterministic results for 2004/05 compared to previously generated results

Year	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Cost per QALY	£5,389	£7,613	£6,844	£9,747	£12,960	£9,887
Health opportunity costs of £10mn (QALYs)	1,856	1,314	1,461	1,026	772	1,011

70. It can be seen from Table A8 that the expected health opportunity costs of a given level of expenditure have increased between 2005/06 and 2004/05 and so the cost per QALY ratio has decreased. The associated uncertainty with each of these results is presented in Table A9 and figures A1 and A2 below.

Table A9 Probabilistic results for 2004/05 expenditure compared to previously generated results

2004/05	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£5,389	£5,377	£4,110	£7,517
Health opportunity costs of £10mn (QALYs)	1,856	1,860	1,330	2,433
2005/06	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£7,613	£7,635	£5,611	£11,619
Health opportunity costs of £10mn (QALYs)	1,314	1,310	861	1,782
2006/07	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£6,844	£6,838	£5,139	£9,878
Health opportunity costs of £10mn (QALYs)	1,461	1,462	1,012	1,946
2007/08	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£9,747	£9,765	£7,689	£13,043
Health opportunity costs of £10mn (QALYs)	1,026	1,024	767	1,301
2008/09	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£12,960	£13,271	£8,390	£32,881
Health opportunity costs of £10mn (QALYs)	772	754	304	1,192
2009/10	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£9,887	£9,920	£6,802	£17,296
Health opportunity costs of £10mn (QALYs)	1,011	1,008	578	1,470

It can be seen from Table A9 that the expected health opportunity costs of a change in expenditure have increased slightly between 2005/06 and 2004/04 and so the cost per QALY ratio has fallen. In this table, the uncertainty associated with these estimates is shown and it can be judged to what extent any changes in the point estimate between years should be interpreted as a signal of any

trend. From Table A9 it is hard to conclude that there is a significant change in the health opportunity costs of £10mn expenditure, since there is a great deal of overlap between the 90% confidence intervals of the years shown. The health opportunity costs of £10mn in 2004/05 are estimated to be significantly greater than those estimated for 2007/08 as shown by the lack of overlap between the 90% confidence intervals.

Figure A1 Results illustrating uncertainty for 2004/05 and previously generated results – cost per QALY

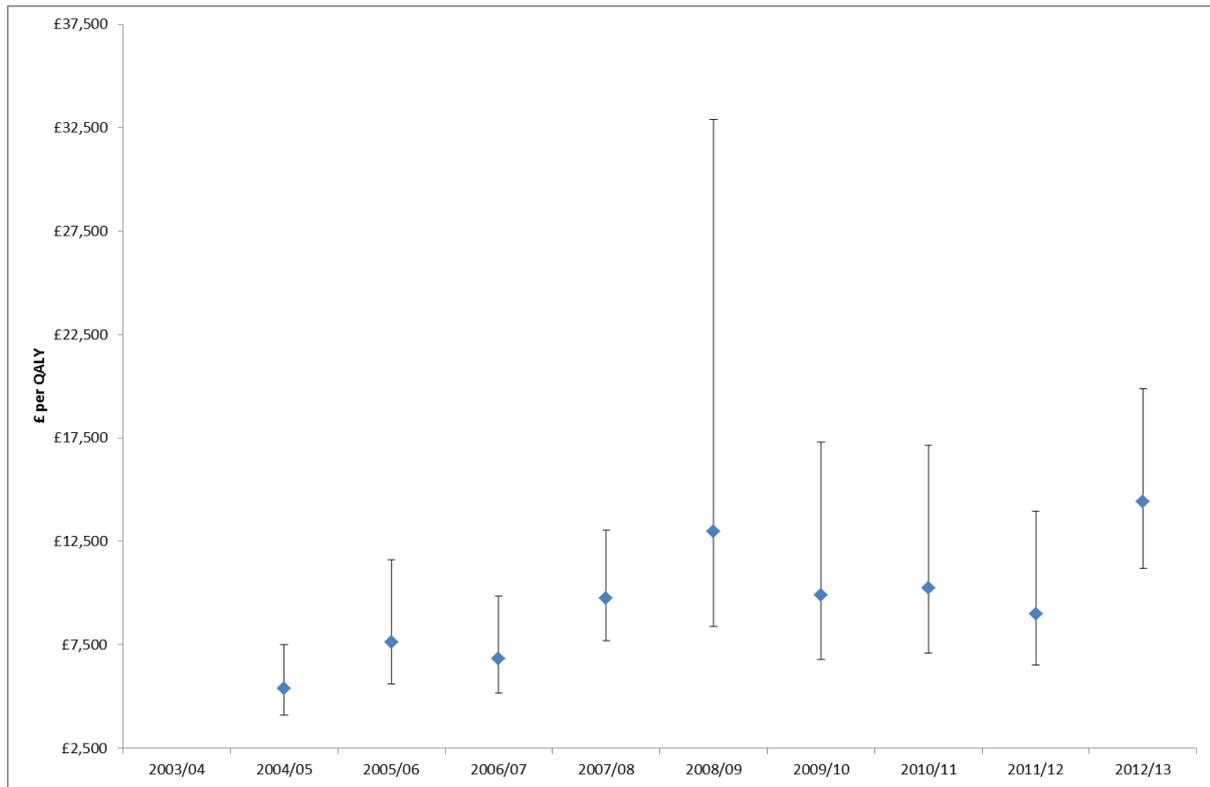
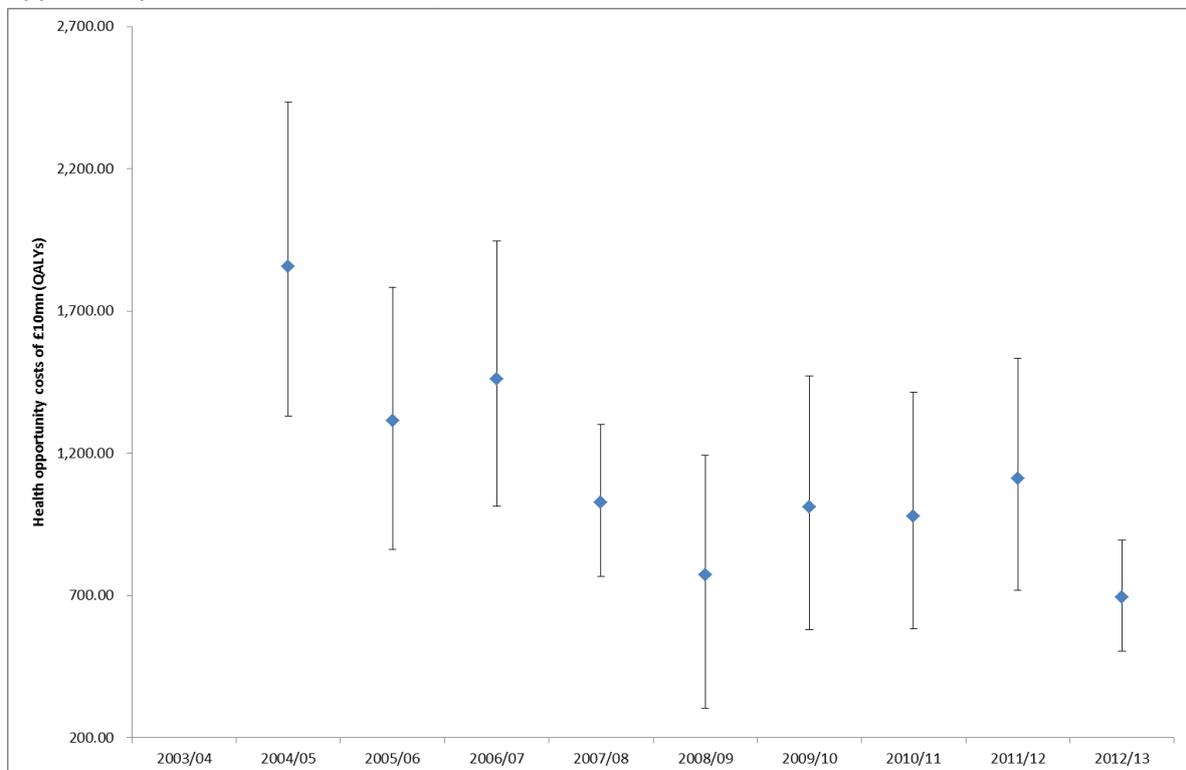


Figure A2 Results illustrating uncertainty for 2004/05 and previously generated results – Health opportunity costs of £10mn (QALYs)



71. It can also be seen from Figures A1 and A2 that while the confidence interval is far from symmetrically distributed around the point estimate of the cost per QALY ratio in Figure A1 (where uncertainty is reflected in the denominator), when expressed as health opportunity costs per £10mn then the distribution of uncertainty is much more symmetric in Figure A2 (uncertainty is reflected in the numerator).

72. It is also possible to generate implied cost per QALY ratio results for each individual PBC. If taken at face values then these results would have important policy implications, for example to divest from one PBC, perhaps maternity and neonates (PBCs 18 and 19), and to invest in another, for example respiratory (PBC 11). There are good reasons why this should not happen, namely potential 'spillovers' between PBCs and the assumption of proportionality between the effect of changes in expenditure on the QALY burden disease and the estimated proportionate effect on the mortality burden, which may be more appropriate for some PBCs than others. In Table A10, we consider how cost per QALY ratios for specific PBCs vary over time.

Table A10 Implied PBC cost per QALY ratios over time

	Implied PBC cost per QALY (£) 2004/05	Implied PBC cost per QALY (£) 2005/06	Implied PBC cost per QALY (£) 2006/07	Implied PBC cost per QALY (£) 2007/08	Implied PBC cost per QALY (£) 2008/09
2 Cancer	£ 18,010.10	£ 27,667.77	£ 18,273.98	£ 17,640.20	£ 17,594.59
10 Circulatory	£ 5,486.45	£ 4,844.61	£ 5,823.96	£ 6,571.01	£ 6,665.70
11 Respiratory	£ 1,121.13	£ 1,394.46	£ 1,295.46	£ 1,971.96	£ 2,151.60
13 Gastro-intestinal	£ 7,380.94	£ 9,954.11	£ 7,290.71	£ 11,292.57	£ 8,602.65
1 Infectious diseases	£ 81,496.11	£ 19,452.54	£ 12,275.48	£ 12,886.90	£ 19,030.88
4 Endocrine	£ 1,385.07	£ 2,916.06	£ 2,078.60	£ 2,198.46	£ 2,270.96
7 Neurological	£ 1,395.10	£ 4,677.53	£ 2,301.18	£ 9,165.34	£ 7,504.74
17 Genito-urinary	£ 71,170.46	£ 78,439.80	£ 116,616.35	£ 33,836.19	£ 2,978,823.26
16 Trauma & injuries*	N/A	N/A	N/A	N/A	N/A
18+19 Maternity & neonates*	£ 3,065,589.00	£ 7,526,403.52	£ 4,613,479.53	£ 6,260,414.86	£ 12,313,490.13
3 Disorders of Blood	£ 3,913.33	£ 4,703.82	£ 4,053.46	£ 5,977.55	£ 8,676.28
5 Mental Health	£ 6,854.56	£ 8,673.25	£ 8,254.65	£ 11,278.69	£ 17,250.44
6 Learning Disability	£ 55,174.37	£ 69,200.60	£ 65,320.04	£ 92,084.50	£ 137,944.35
8 Problems of Vision	£ 18,293.13	£ 21,838.83	£ 18,951.38	£ 27,118.28	£ 42,138.55
9 Problems of Hearing	£ 2,308.45	£ 2,675.78	£ 2,407.59	£ 3,935.06	£ 5,753.54
12 Dental problems	£ 4,390.74	£ 9,432.19	£ 17,863.94	£ 25,722.64	£ 39,088.10
14 Skin	£ 37,032.09	£ 46,661.01	£ 44,709.25	£ 60,419.56	£ 92,974.01
15 Musculo skeletal	£ 6,699.23	£ 8,159.61	£ 6,620.05	£ 9,469.74	£ 14,382.87
20 Poisoning and AE	£ 36,384.72	£ 49,191.19	£ 45,750.52	£ 62,464.12	£ 104,500.87
21 Healthy Individuals	£ 159,784.55	£ 214,734.17	£ 200,069.12	£ 294,658.13	£ 484,677.80
22 Social Care Needs	N/A	N/A	N/A	N/A	N/A
23 Other	N/A	N/A	N/A	N/A	N/A

73. The results in Table A10 for each PBC are largely driven by two key variables: each PBC's estimated outcome elasticity and the changing burden of disease for PBCs. Expenditure elasticities only affect PBCs without a mortality signal through the mortality elasticity used for extrapolation, which depends upon expenditure elasticities. As a result, the variations observed in Table A10 reflect variations that can be seen in the elasticities found in Table A1.

Appendix 2.2 Sensitivity analysis

74. Appendix 2.2 details three sensitivity analyses that were performed. The first two concerned the elasticities that were econometrically estimated for each of the PBCs. In the first case each of the estimated PBC outcome elasticities are varied by +/- 1 standard error. Then, the difference between the two resulting opportunity costs is presented. When this is larger, this implies that the overall resulting estimate of health opportunity costs is more sensitive to the outcome elasticity under consideration. The same procedure is then carried out for each of the PBC expenditure elasticities. The results of these sensitivity analyses are reported in Tables A11 and A12.

Table A11 Sensitivity of results to estimated outcome elasticities

	Change in spend	Change in QALY death + QALY alive	Implied PBC cost per QALY (£)	Difference in health opportunity costs between +1 SE and -1 SE in PBC outcome elasticity	% difference in health opportunity costs between +1 SE and -1 SE in PBC outcome elasticity	Importance of PBC (rank)	Importance of PBC (rank) 2005/06	Importance of PBC (rank) 2006/07	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2 Cancer	£ 891,450.47	49	£ 18,010.10	68	3.69%	6	6	6	5	6
10 Circulatory	£ 1,894,857.91	345	£ 5,486.45	165	8.89%	3	3	2	3	4
11 Respiratory	£ 736,592.21	657	£ 1,121.13	512	27.58%	1	1	1	1	2
13 Gastro-intestinal	£ 636,959.01	86	£ 7,380.94	70	3.80%	5	5	4	4	5
1 Infectious diseases	£ 176,604.68	2	£ 81,496.11	5	0.28%	8	7	7	8	7
4 Endocrine	£ 171,098.38	124	£ 1,385.07	156	8.39%	4	4	3	2	3
7 Neurological	£ 305,588.04	219	£ 1,395.10	226	12.17%	2	2	5	6	1
17 Genito-urinary	£ 418,666.65	6	£ 71,170.46	11	0.59%	7	8	8	7	8
16 Trauma & injuries*	£ 389,471.23	0	N/A	-	-	-	-	-	-	-
18+19 Maternity & neonates*	£ 438,369.80	0	£ 3,065,589.00	0	0.01%	9	9	9	9	9
3 Disorders of Blood	£ 151,688.57	39	£ 3,913.33	-	-	-	-	-	-	-
5 Mental Health	£ 1,374,915.71	201	£ 6,854.56	-	-	-	-	-	-	-
6 Learning Disability	£ 181,316.31	3	£ 55,174.37	-	-	-	-	-	-	-
8 Problems of Vision	£ 349,845.26	19	£ 18,293.13	-	-	-	-	-	-	-
9 Problems of Hearing	£ 31,185.53	14	£ 2,308.45	-	-	-	-	-	-	-
12 Dental problems	£ 107,731.54	25	£ 4,390.74	-	-	-	-	-	-	-
14 Skin	£ 138,849.80	4	£ 37,032.09	-	-	-	-	-	-	-
15 Musculo skeletal	£ 381,162.46	57	£ 6,699.23	-	-	-	-	-	-	-
20 Poisoning and AE	£ 193,346.73	5	£ 36,384.72	-	-	-	-	-	-	-
21 Healthy Individuals	£ 151,313.90	1	£ 159,784.55	-	-	-	-	-	-	-
22 Social Care Needs	£ 380,662.29	0	N/A	-	-	-	-	-	-	-
23 Other	£ 498,323.53	0	N/A	-	-	-	-	-	-	-

Total: 1,856

Table A12 Sensitivity of overall results to estimated spend elasticities

	Change in spend	Change in QALY death + QALY alive	Implied PBC cost per QALY (£)	Difference in health opportunity costs between +1 SE and -1 SE in PBC spend elasticity	% difference in health opportunity costs between +1 SE and -1 SE in PBC spend elasticity	Importance of PBC (rank)	Importance of PBC (rank) 2005/06	Importance of PBC (rank) 2006/07	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2 Cancer	£ 891,450.47	49	£ 18,010.10	66	3.58%	4	4	8	8	11
10 Circulatory	£ 1,894,857.91	345	£ 5,486.45	26	1.41%	12	2	9	2	2
11 Respiratory	£ 736,592.21	657	£ 1,121.13	174	9.37%	1	1	1	1	1
13 Gastro-intestinal	£ 636,959.01	86	£ 7,380.94	20	1.08%	14	12	18	12	13
1 Infectious diseases	£ 176,604.68	2	£ 81,496.11	18	1.00%	16	14	19	21	19
4 Endocrine	£ 171,098.38	124	£ 1,385.07	33	1.78%	10	11	12	10	3
7 Neurological	£ 305,588.04	219	£ 1,395.10	69	3.70%	3	19	6	19	18
17 Genito-urinary	£ 418,666.65	6	£ 71,170.46	63	3.42%	5	5	4	11	6
16 Trauma & injuries*	£ 389,471.23	0	N/A	78	4.22%	2	3	7	6	8
18+19 Maternity & neonates*	£ 438,369.80	0	£ 3,065,589.00	50	2.67%	8	7	2	5	4
3 Disorders of Blood	£ 151,688.57	39	£ 3,913.33	8	0.43%	21	15	20	18	22
5 Mental Health	£ 1,374,915.71	201	£ 6,854.56	19	1.00%	15	20	15	20	12
6 Learning Disability	£ 181,316.31	3	£ 55,174.37	35	1.91%	9	9	5	7	10
8 Problems of Vision	£ 349,845.26	19	£ 18,293.13	22	1.17%	13	13	16	15	17
9 Problems of Hearing	£ 31,185.53	14	£ 2,308.45	12	0.65%	18	17	17	13	20
12 Dental problems	£ 107,731.54	25	£ 4,390.74	5	0.25%	22	21	11	14	14
14 Skin	£ 138,849.80	4	£ 37,032.09	15	0.81%	17	16	14	16	16
15 Musculo skeletal	£ 381,162.46	57	£ 6,699.23	8	0.43%	20	22	22	22	21
20 Poisoning and AE	£ 193,346.73	5	£ 36,384.72	11	0.58%	19	18	21	17	15
21 Healthy Individuals	£ 151,313.90	1	£ 159,784.55	31	1.70%	11	10	13	9	5
22 Social Care Needs	£ 380,662.29	0	N/A	55	2.96%	6	6	10	3	7
23 Other	£ 498,323.53	0	N/A	53	2.84%	7	8	3	4	9
Total:		1,856								

75. Generally, the results display varying degrees of sensitivity to estimated elasticities depending upon the PBC under consideration. In general, but not always, the results are more sensitive to specific PBC outcome elasticities than to specific PBC spend elasticities. Looking first at Table A12, the difference between the overall health opportunity cost when the spend elasticity is increased by one standard error compared to the result when the standard error is reduced by one standard error represents more than 10% for no single PBC (PBC 11 (respiratory) has the highest difference at 9.37%). Switching to look at Table A11 it can be seen that the most important PBC in terms of outcome elasticity sensitivity is PBC 11: respiratory, as it is when spend elasticity is considered. The overall estimated health opportunity cost is also sensitive to PBC 7 (neurological).

76. Following these two sensitivity analyses, a third is performed with a different emphasis, which analyses the sensitivity of the overall health opportunity cost estimate to two key assumptions:

Surrogacy- we are required to make an assumption about how the effect on mortality for PBCs with a mortality indicator can be used as a *surrogate* for the effect that expenditure has on morbidity (or health-related quality of life) in those PBCs.

Extrapolation- We are required to make an assumption about how the estimated effects on mortality found for PBCs with a mortality indicator can be *extrapolated* to the effect that expenditure has on mortality for those PBCs that do not have a mortality indicator.

In order to assess the impact of these assumptions on the overall results for the NHS, we evaluate the health effects of £10mn spending at the margin in the NHS when either:

- a) For PBCs with a mortality indicator: no surrogacy assumption, therefore expenditure has no effect on morbidity
- b) For PBCs without a mortality indicator: assume no health effects at all, neither on mortality (extrapolation assumption) nor morbidity (surrogacy assumption)

The results are found here in Table A13.

Table A13 Sensitivity of overall results to surrogacy and extrapolation assumptions

	Change in spend	Change in QALY death	Change in QALY alive	Health opportunity costs sensitivity to mortality/morbidity assumption (%)	Importance of PBC (rank)	Importance of PBC (rank) 2005/06	Importance of PBC (rank) 2006/07	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2 Cancer	£ 891,450.47	46	4	-0.19%	15	16	15	14	14
10 Circulatory	£ 1,894,857.91	234	111	-5.98%	5	3	4	3	5
11 Respiratory	£ 736,592.21	14	643	-34.66%	1	1	1	1	1
13 Gastro-intestinal	£ 636,959.01	31	56	-3.00%	7	7	6	5	6
1 Infectious diseases	£ 176,604.68	0	2	-0.09%	17	12	11	10	10
4 Endocrine	£ 171,098.38	6	117	-6.31%	4	6	3	4	4
7 Neurological	£ 305,588.04	10	209	-11.26%	2	4	5	7	3
17 Genito-urinary	£ 418,666.65	1	5	-0.25%	13	13	13	11	18
16 Trauma & injuries*	£ 389,471.23	0	0	0.00%	-	-	-	-	-
18+19 Maternity & neonates*	£ 438,369.80	0	0	0.00%	19	19	19	19	19
3 Disorders of Blood	£ 151,688.57	2	37	-2.09%	8	8	8	8	9
5 Mental Health	£ 1,374,915.71	18	183	-10.81%	3	2	2	2	2
6 Learning Disability	£ 181,316.31	1	3	-0.18%	16	17	17	17	15
8 Problems of Vision	£ 349,845.26	1	18	-1.03%	10	11	12	12	12
9 Problems of Hearing	£ 31,185.53	0	13	-0.73%	11	10	9	9	8
12 Dental problems	£ 107,731.54	0	25	-1.32%	9	9	10	13	11
14 Skin	£ 138,849.80	1	2	-0.20%	14	15	14	16	13
15 Musculo skeletal	£ 381,162.46	3	54	-3.07%	6	5	7	6	7
20 Poisoning and AE	£ 193,346.73	1	4	-0.29%	12	14	16	15	16
21 Healthy Individuals	£ 151,313.90	0	1	-0.05%	18	18	18	18	17
22 Social Care Needs	£ 380,662.29	0	0	0.00%	-	-	-	-	-
23 Other	£ 498,323.53	0	0	0.00%	-	-	-	-	-
Total:		369	1,486						
Total change in QALY death + QALY alive			1,856						

77. It can be seen that the surrogacy assumption is especially impactful for PBCs 11 and 7 (respiratory and neurological). Extrapolation and surrogacy is particularly important for PBC 5 (mental health).

Appendix 2.3 Outline of ONS data update for 2004/05

78. The calculation of net YLL by PBC relies on two crucial inputs. The first is data on deaths within each PBC and the age of death, which is then compared to the benchmark of the second input, PBC life expectancy. Each death can then be translated into a number of years of life lost (YLL) if death occurred before the life expectancy and years of life gained (YLG) when the death occurred after the life expectancy. The difference between YLL and YLG gives net YLL, which is an input into the calculation of results. PBC life expectancy itself has to be calculated and relies on data provided by national life tables.

Table A14 Net YLL for 2004-2006, 2005-2007, 2006-2008, 2007-2009, 2008-2010 and 2009-2011 using LE for each PBC

2004-2006

PBC	GP LE (M)	GP LE (F)	PBC LE (M)	PBC LE (F)	All deaths	Net YLL
1	79.1	83.3	79.1	83.3	5,878	34,732
2	82.5	84.4	82.5	84.4	129,352	1,312,944
4	80.4	84.4	80.4	84.4	6,835	49,192
7	79.1	82.9	79.1	82.9	14,024	89,958
10	82.5	86.2	82.5	86.2	171,100	851,860
11	79.7	83.6	79.7	83.6	65,824	37,350
13	80.0	84.1	80.0	84.1	23,739	210,088
17	83.1	85.2	83.1	85.2	9,494	16,353
18+19	78.2	82.7	78.2	82.7	228	16,812

2005-2007

PBC	GP LE (M)	GP LE (F)	PBC LE (M)	PBC LE (F)	All deaths	Net YLL
1	79.4	83.4	79.4	83.4	6,874	33,965
2	82.8	84.5	82.8	84.5	129,927	1,327,521
4	80.7	84.6	80.7	84.6	6,755	49,589
7	79.4	83.1	79.4	83.1	14,591	91,452
10	82.7	86.3	82.7	86.3	164,630	824,599
11	80.0	83.8	80.0	83.8	65,660	47,301
13	80.3	84.3	80.3	84.3	23,947	217,025
17	83.3	85.4	83.3	85.4	10,100	16,381
18+19	78.5	82.9	78.5	82.9	215	15,833

2006-2008

PBC	GP LE (M)	GP LE (F)	PBC LE (M)	PBC LE (F)	All deaths	Net YLL
1	79.6	83.6	79.6	83.6	6,958	36,379
2	83.0	84.7	83.0	84.7	130,810	1,347,324
4	81.0	84.7	81.0	84.7	6,765	50,933
7	79.6	83.3	79.6	83.3	15,353	92,710
10	83.0	86.5	83.0	86.5	159,852	808,850
11	80.3	84.0	80.3	84.0	65,446	61,007
13	80.6	84.5	80.6	84.5	24,147	226,380
17	83.5	85.6	83.5	85.6	10,624	16,669
18+19	78.7	83.1	78.7	83.1	226	16,801

2007-2009

PBC	GP LE (M)	GP LE (F)	PBC LE (M)	PBC LE (F)	All deaths	Net YLL
1	79.8	83.8	79.8	83.8	6,288	38,835
2	83.2	84.9	83.2	84.9	131,372	1,355,804
4	81.2	84.9	81.2	84.9	6,762	51,857
7	79.9	83.5	79.9	83.5	16,076	91,442
10	83.2	86.6	83.2	86.6	155,222	785,989
11	80.5	84.2	80.5	84.2	65,026	73,441
13	80.8	84.7	80.8	84.7	23,920	227,224
17	83.7	85.7	83.7	85.7	11,015	15,310
18+19	79.0	83.2	79.0	83.2	255	18,899

2008-2010

PBC	GP LE (M)	GP LE (F)	PBC LE (M)	PBC LE (F)	All deaths	Net YLL
1	81.2	84.8	80.1	84.0	5,262	44,445
2	81.2	84.8	83.4	85.1	131,945	1,199,680
4	81.2	84.8	81.4	85.1	6,763	49,504
7	81.2	84.8	80.1	83.7	16,771	111,501
10	81.2	84.8	83.4	86.8	151,443	459,945
11	81.2	84.8	80.7	84.4	64,449	112,633
13	81.2	84.8	81.0	84.9	23,898	231,757
17	81.2	84.8	83.9	85.9	11,345	4,085
18+19	81.2	84.8	79.3	83.5	265	20,332

2009-2011

PBC	GP LE (M)	GP LE (F)	PBC LE (M)	PBC LE (F)	All deaths	Net YLL
1	80.5	84.3	80.5	84.3	4,907	38,814
2	83.7	85.4	83.7	85.4	132,656	1,395,819
4	81.7	85.4	81.7	85.4	6,477	51,079
7	80.5	84.0	80.5	84.0	17,113	93,164
10	83.6	87.1	83.6	87.1	142,567	768,320
11	81.1	84.7	81.1	84.7	63,088	101,927
13	81.4	85.2	81.4	85.2	23,499	235,041
17	84.1	86.2	84.1	86.2	10,600	16,230
18+19	79.7	83.8	79.7	83.8	252	18,895

Appendix 2.4 Calculation of elasticity for extrapolation and overall NHS mortality elasticities

79. Whilst we have estimated outcome elasticities for PBCs 2, 10, 11, 13, 1, 4, 7, 17 and 18+19, we can also use these to generate an overall to compare with a vast body of literature that estimates the elasticity of all-cause mortality with respect to health care expenditure (Andrews et al., 2016 report an elasticity for 2005/6 English NHS as 0.71). It is worth noting that direct comparison is not possible, since there are substantial methodological differences across publications. An important consideration is that all-cause models may find it harder to detect signal rather than noise, which may cancel out signal, compared to an approach that uses disease-specific models to estimate the effect of expenditure on mortality. The results for an overall mortality elasticity are presented below in Table A15.

Table A15 Estimated overall elasticities

	Elasticity comparable to all-cause model results
2009/10	0.94
2008/9	0.80
2007/8	1.27
2006/7	1.50
2005/6	1.37
2004/5	1.62